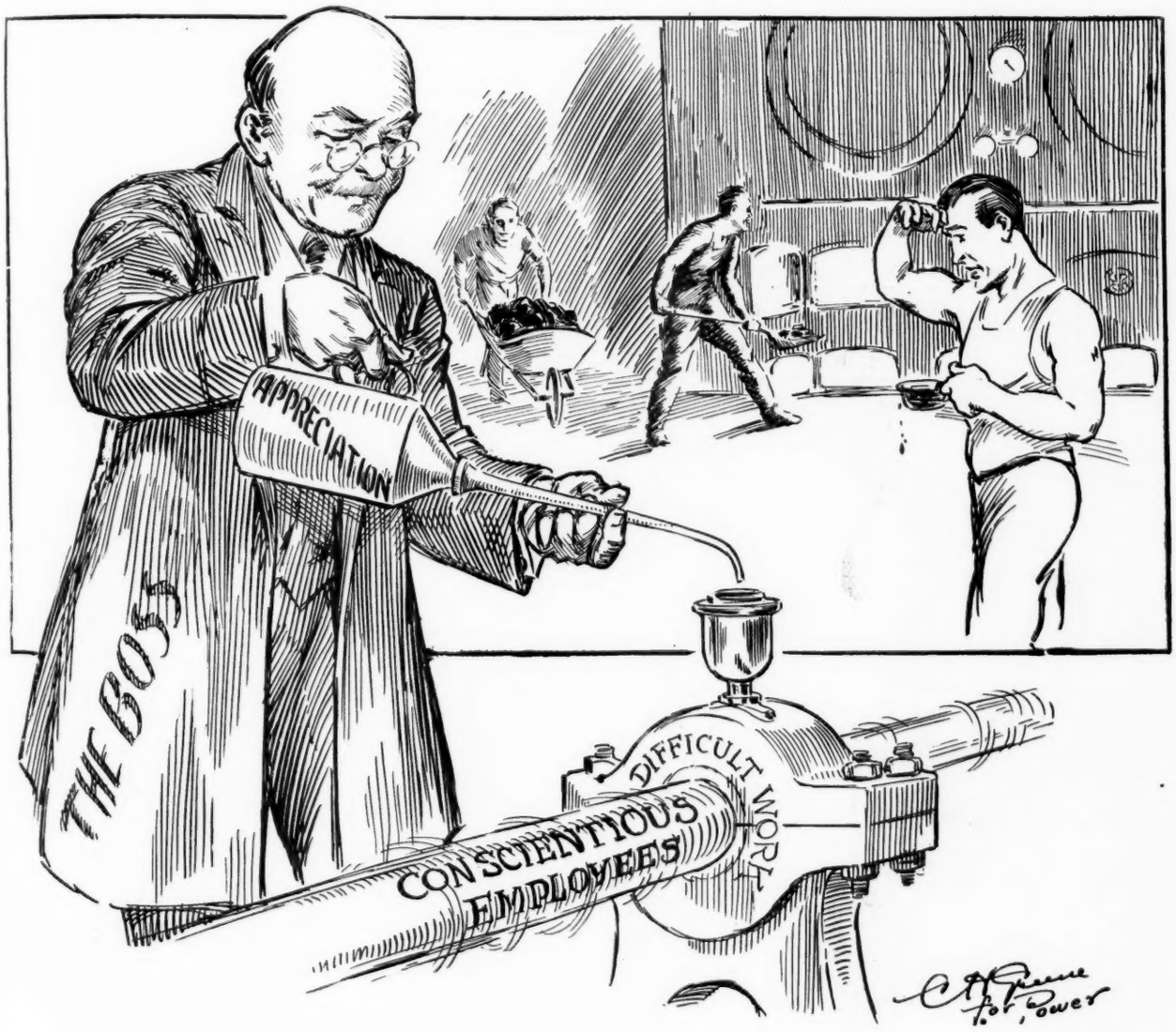
POWER

Vol. 46 NEW YORK, DECEMBER 4, 1917 No. 23



A Good Lubricant—
A Little Goes A Long Ways

One-Hundred-and-Ten-Million Gallon Pump for St. Louis

By H. F. GAUSS

A turbine-driven 13-stage centrifugal pump having a maximum capacity of 110,000,000 gal. against head of 65 feet. Under normal conditions a pump efficiency of 81 per cent. is expected and a duty exceeding 114,500,000 ft.-lb. per million B.t.u.

THE City of St. Louis has recently let a contract for adding 110,000,000 gal. to its low-service pumping capacity, which at present is 180,000,000 gal. per 24 hours. The new unit is to be a steam-turbine-driven centrifugal pump and will be completed and ready for service in June, 1918. The latest addition of low-service pumps was made in 1912, when two 20,000,000-gal. direct-acting pumps were replaced with two 30,000,000-gal. turbine-driven centrifugals located in the bottom of the former pump pits. In the present pumping station are three pits, known as the north, middle and south pits respectively. The middle pit, shown in Fig. 1, contains the two 30,000,000-gal. turbine-driven centrifugal pumps and will also contain the new 110,000,000-gal. pump. All three pits are 50 ft. square at the bottom by 57 ft. deep below the ground floor. The new pump is to be built on foundations prepared by the Water Division which are at present under way.

Fig. 2 is a plan and vertical section through the pump pit looking north, showing the suction and discharge piping for the new unit. To provide room for the suction valve, which will be a 60-in. hydraulically operated gate, it was necessary to channel away 3 ft. of the ledge on the east side of the pit. By removing this ledge the entire length of the pit down to the elevation of the operating floor, a convenient location for auxiliary apparatus was secured, also easy access to all parts of the new unit itself.

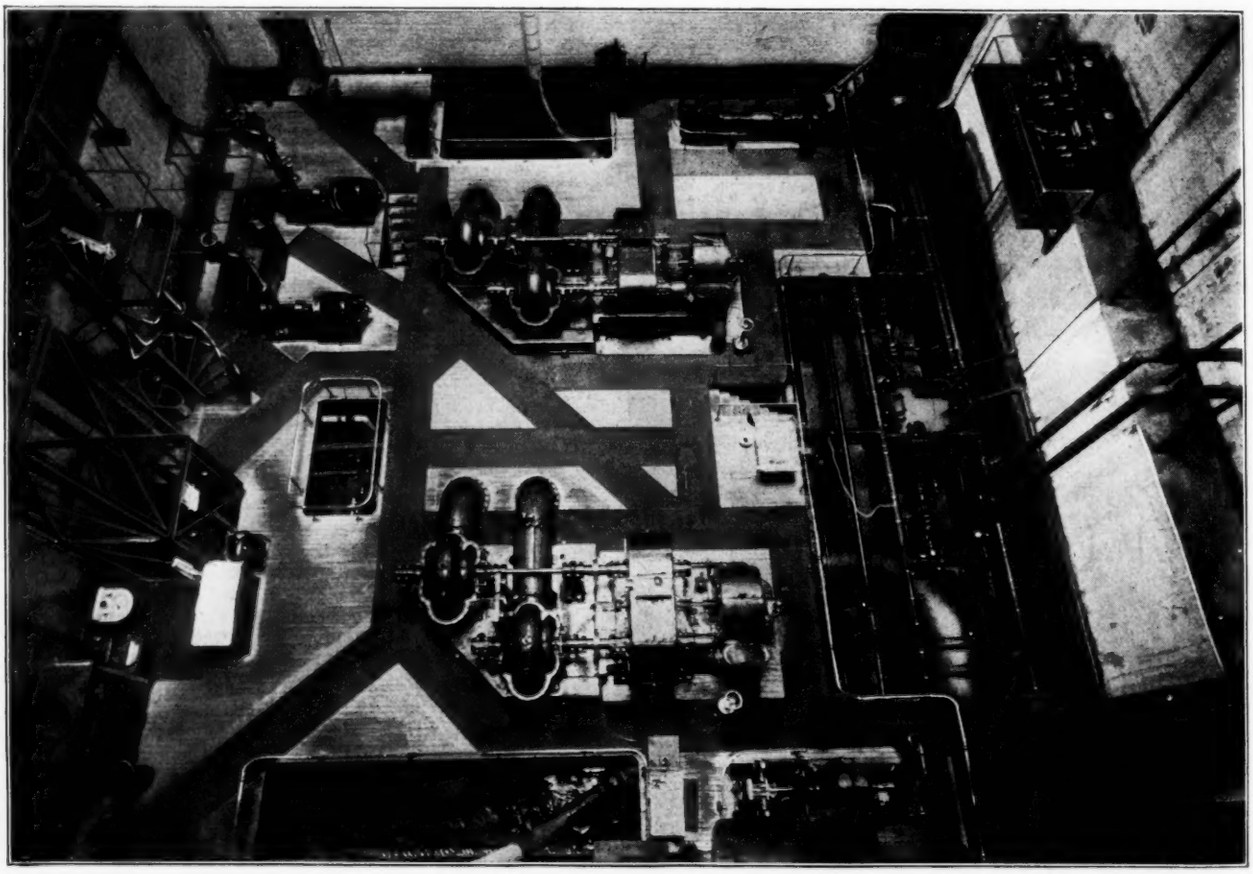


FIG. 1. MIDDLE PIT, IN WHICH NEW UNIT WILL BE PLACED

Fig. 4 is a photograph showing the ledge in process of being channeled away. It is composed of bed limestone and is part of a solid rock wall 40 ft. thick between the suction or so-called wet well and the middle pit. The suction connection to the wet well for the new pump will be 60 in. diameter and located on the center line of the middle pit. In addition to the 60-in. hydraulically operated gate valve mentioned, iron frames will be provided in the wet well for holding

stop logs should it ever be necessary to bulkhead the suction pipe and work on the gate valve.

In the pit the operating floor is 12 ft. above the bottom, and the top of the bedplate of the new unit will be 18 in. above the operating floor. The average net discharge head will be 60 ft. The discharge pipe is to be 60 in. diameter and will drop below the operating floor, rising vertically at the west pump-pit wall, where a 60-in. hydraulic gate valve will be located, beyond which the pipe will be increased to 72 in. to accommodate the discharge from one of the present centrifugals, which is to be connected in with a 72 x 60 x 42-in. "Y" branch. The 72-in. discharge line will be carried to the top of the pit, whence it will continue to the delivery well 158 ft. west of the engine room. Between the engine room and the delivery well the discharge line will contain a venturi meter tube, the overall length of which will be 48 ft. 10 in. and the throat diameter 3 ft. This will be the largest cast-iron meter tube yet built and will be capable of measuring from 20 to 150 million gallons per 24 hours. There will be provided an indicating, recording and integrating device connected to the meter tube by means of brass piping and located on the ground floor of the engine room. Fig. 2 shows the meter tube in place. Fig. 3 is an elevation of the new unit complete.

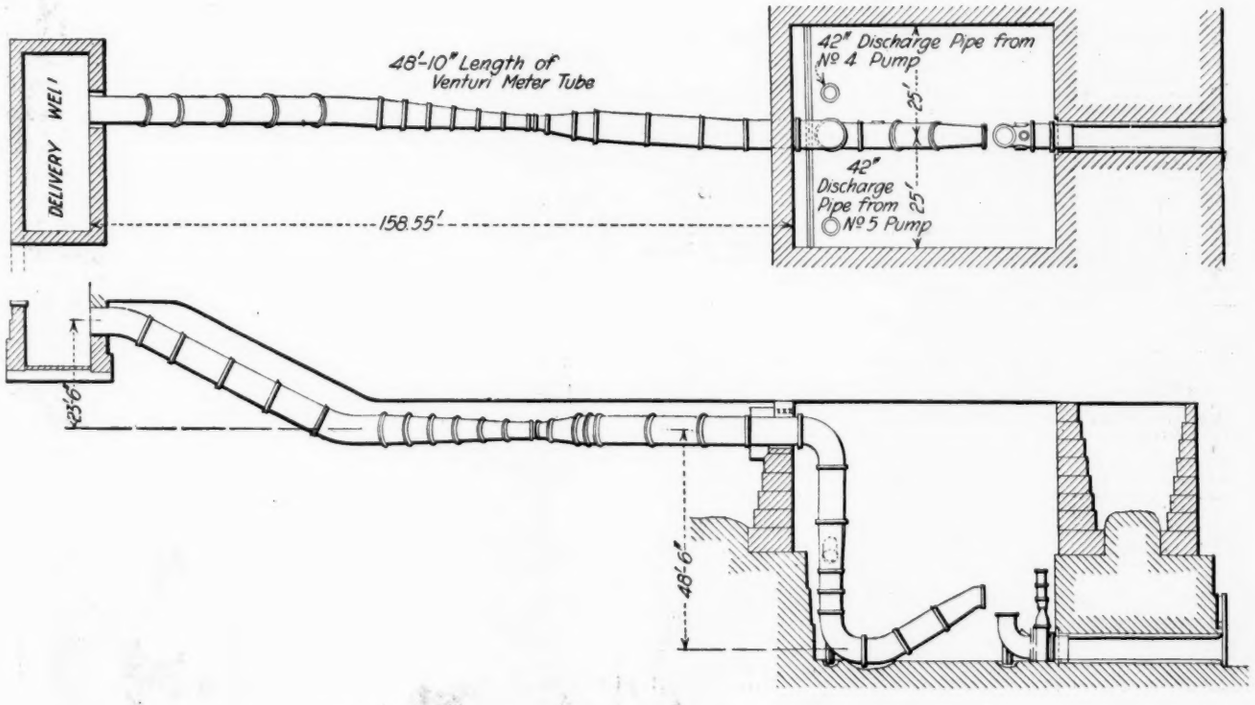


FIG. 2. SUCTION AND DISCHARGE PIPING FOR NEW UNIT

While 110,000,000 gal. per 24 hours is to be the maximum pumping capacity, a range of flexibility is required which imposes rather difficult conditions on the water end of the unit as well as on the governor controlling the speed of the turbine. The specifications require that the pump be capable of delivering from 80 to 110 million gallons at any net head between 45 and 65 ft. The necessary speed adjustment to secure this variation in delivery is to be obtained by a sufficient number of hand-controlled nozzles in the admission end of the turbine. However, the unit is to be entirely under the control of the governor after the necessary hand regulation is complete.

The steam end of the unit is being designed for a steam pressure of 125 lb. gage, superheat of 75 deg. F., temperature of circulating water 35 to 80 deg., vacuum 1 to 2 in. of mercury. The throttle is to be a combination steel automatic stop and throttle valve capable of being set to stop the turbine independently of the governor should a predetermined speed be exceeded. The safety governor will be mounted on the end of the main turbine shaft entirely independent of the main speed governor and will be arranged to be tripped by hand should occasion demand. The main speed governor is to be of the oil relay type mounted on a vertical shaft and worm-driven from the main turbine shaft. It will be constructed to permit of adjustment while the turbine is in operation to any point within the required range of speed and, after being adjusted, will be capable of maintaining the speed within a 2 per cent. variation above or below.

The turbine will be of the horizontal bleeder multistage impulse type, having a normal rating of 1300 b.hp. at 3510 revolutions per minute. The maximum water horsepower including pipe friction will be 1250 and the maximum horsepower of the turbine, 1550.

A bleeder connection into one of the low-pressure stages of the turbine will be provided and furnished with an automatic pressure valve designed to maintain a constant pressure not to exceed 5 lb. gage in the feed-water heating system. The amount of steam bled will be such that in no case will the auxiliary steam plus the bled steam exceed 2200 lb. per hour.

The condensing equipment will consist of a surface water-tube condenser, single-pass for steam and two-pass for water; a 7 and 16 by 14-in. rotative dry-

vacuum pump, a turbine-driven 2½-in. double-suction centrifugal condensate pump and a 12-in. centrifugal circulating pump direct-connected to the main pump shaft. The condenser will contain a primary heater

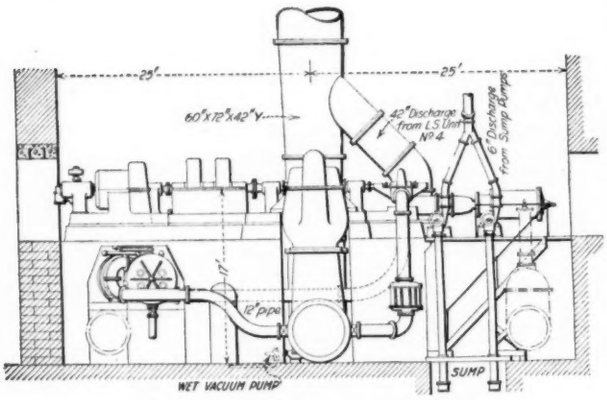


FIG. 3. ELEVATION OF NEW UNIT

having 125 sq.ft. of heating surface, located directly below the exhaust inlet. There will be a total of 2825 sq.ft. of condensing surface composed of seamless drawn brass tubes of No. 18 B.w.g. 1 in. diameter outside and 12 ft. long.

PHYSICAL DATA OF PUMPING UNIT AND AUXILIARIES

Turbines

Make	De Laval
Brake hp. of turbine	Normal, 1,300; max. 1,550
Number of stages	13
Number and diameter of rotors	4 27½-in.; 9 34-in.
R.p.m. under max. conditions	3,720
Method of speed control	Jahns governor through oil relay
Percentage of speed obtainable above and below normal by governor regulation	6 above and 15 below
Percentage of speed obtainable above and below normal by hand-regulated nozzle	Approx. 6 above and 20 below
Net weight of turbine without bedplate, lb	24,000
Diameter and length of bearings, in	4½x14
Diameter of shaft in rotor, in	10
Diameter of steam admission, in	6
Diameter of steam exhaust, in	36

Reduction Gear

Net weight of reduction gear complete without bedplate, lb	32,000
Diameter of driven gear, in	63.4
Diameter of pinion, in	6
Width of face of gear in pinion, in	29¼
Tooth pressure per inch, face of gear and pinion, when pump is delivering 110,000,000 gal. per day at 65 ft. head, lb	300
Gear ratio	10.56 to 1
Angle of gear tooth, deg	45
Mechanical efficiency of gear, per cent	98
Hp. consumed by gear under max. conditions	31

Pump

Net weight of pump without bedplate, lb	40,000
Net weight of bedplate for complete unit, lb	15,000
Diameter of impellers, in	50
Diameter of shaft at impeller, in	8
Diameter and length of bearings	One 6½x18; one 5½x18
Length of shaft between bearings	8 ft. 4 in.
Revolutions per minute, max	352
Diameter of water suction, in	48
Diameter of water discharge, in	48
Efficiency of pump, per cent	81

Condenser

Condensing surface, sq.ft	2,825
Diameter of tubes, in	1
Gage of tubes	No. 18 B.w.g.
Length of tubes, ft	12
Number of steam passes	1
Number of water passes	2
Size of exhaust-steam inlet, in	36
Net weight of condenser, lb	20,800
Diameter of condenser shell, ft	5
Length of shell	14 ft. 9 in.

Air Pump

Revolutions per minute	115
Size of inlet, in	5
Size of outlet, in	3
Method of driving air pump	By steam cylinders
Weight of air pump complete, lb	6,400

Condensate Pump

Size of pump, in	2½
Revolutions per minute	1,800
Size of inlet, in	2½
Size of outlet, in	2½

The circulating pump will be of the same general design as the main pump. It will take its suction from the inlet pipe for the main pump, and the water, after passing through the condenser, will be discharged back into the main suction pipe. The main pump will be driven through a double helical reduction gear having a ratio of 10.56 to 1, the pinion running normally at 3510 r.p.m. and the gear at 332. The efficiency of transmission under these conditions will be 98 per cent. The suction inlet of the main pump will be 48 in. diameter, and the discharge outlet the same size. When operating at a speed of 332 r.p.m., the pump is to deliver 100,000,000 U. S. gal. of water against a total net gage head of 60 ft. with an efficiency of not less than 81 per cent., requiring 1300 b.hp. to drive it.

At present the feed-water heating equipment consists of two closed heaters, to which are piped the exhaust steam from the various auxiliary apparatus about the station. A common exhaust header in which the pressure does not exceed 5 lb. gage receives the exhaust steam and carries it to the heaters. It is proposed to bleed steam from one of the low-pressure stages of the turbine into this exhaust header. The duty of the unit based on the work done per million B.t.u. used will be determined by dividing the total work done in foot-pounds per hour by the total heat in the steam delivered to the turbine and auxiliaries per hour above 32 deg. minus the heat which is reclaimed by the primary heater in the condenser, the heat reclaimed in the closed heaters and the heat above 32 deg. in condensate from the heaters.

The duty on which the guarantees are based was arrived at as follows: Circulating-water temperatures were assumed at 50 and 80 deg., and the duty obtainable at these temperatures for the heads of 45, 60 and 65 ft. were averaged for each of the three deliveries; namely, 100 million, 110 million and 80 million gallons per day respectively. The average duties for the 60- and 65-ft. heads were then multiplied by 2 and added to the average duty for the 45-ft. head. The sum thus ob-

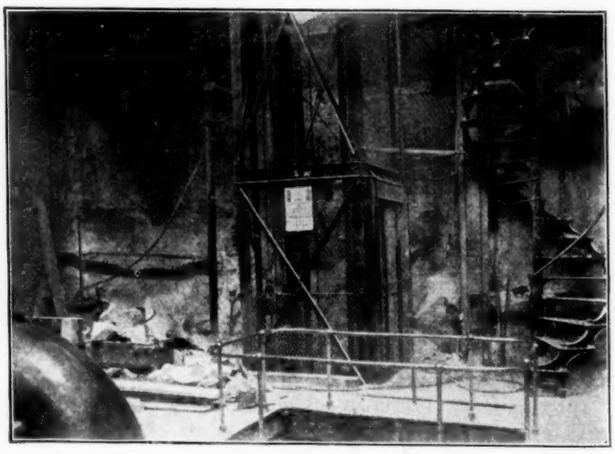


FIG. 4. CHANNELING LEDGE FROM SOLID ROCK WALL ON EAST SIDE OF PIT

tained was divided by 5 and termed the average duty for the respective capacities. The average duty at 100 million gallons per day was multiplied by 2 and added to those for 80 and 110. The sum was then divided by

4, giving the resultant duty sought. The scheme may be represented diagrammatically as follows:

100 MILLION GALLONS DELIVERED

$$\frac{\text{Duty at 50 deg.} + \text{duty at 80 deg.}}{2} \text{ for 45 ft. head} \times 1 =$$

for 60 ft. head × 2 =
for 65 ft. head × 2 =

5) Sum

Duty A

80 MILLION GALLONS DELIVERED

$$\frac{\text{Duty at 50 deg.} + \text{duty at 80 deg.}}{2} \text{ for 45 ft. head} \times 1 =$$

for 60 ft. head × 2 =
for 65 ft. head × 2 =

5) Sum

Duty B

110 MILLION GALLONS DELIVERED

$$\frac{\text{Duty at 50 deg.} + \text{duty at 80 deg.}}{2} \text{ for 45 ft. head} \times 1 =$$

for 60 ft. head × 2 =
for 65 ft. head × 2 =

5) Sum

Duty C

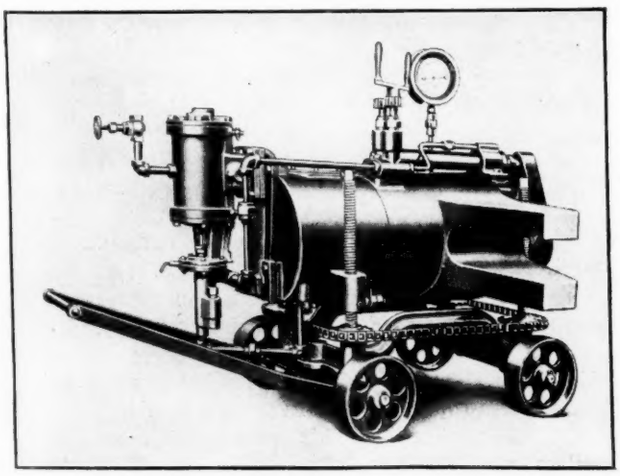
$$\text{Resultant duty} = \frac{2 \times \text{duty A} + \text{duty B} + \text{duty C}}{4}$$

The guaranteed duty thus obtainable will be 114,562,000 ft.-lb. per million B.t.u.

Portable Crankpin Press

Some interesting features are embodied in the design of a new type of portable press for forcing crankpins into engine crank disks and for miscellaneous shop and field forcing work.

The main portion of the press consists of a steel cylinder on the sides of which are cast heavy forks



PORTABLE CRANKPIN PRESS

(see illustration) which support tie-rods. A reservoir is mounted on the rear of the press, and the ram operates from the front of the cylinder casting. The whole unit is carried on screws that are mounted on a flat-wheeled truck. By turning any one of the screws the center line of the ram can be raised or lowered to meet the center line of the pin. Two tie-rods and an abutment beam are used in connection with the press. The distance between the rods is adjustable in the forks so that the rods may be spaced as desired to suit practically every condition.

The ordinary hand air pump is replaced by one driven by an air engine. To make the power connections it is only necessary to run a rubber hose or other flexible tubing from the shop air main to the pump engine, as is done with pneumatic tools. The operating valves are so placed that the man in charge can operate the press in addition to directing the work of his men. The use of the air pump, therefore, eliminates one man, the hand-pump operator, from the crew and increases the speed approximately 300 per cent.

The press is equipped with a gage that indicates the pressure required to seat the pin. By this means it is easy to detect a loose fit, which might seriously endanger the construction of an engine. The ram is returned by a small hydraulic cylinder mounted on the top of the press, with the piston connected to a lug on the end of the ram. All movements of the ram are controlled by a geared screw-stem valve. These presses are built in capacities ranging up to 300 tons, by the Watson-Stillman Co., Aldene, N. J.

Series-Field Winding Cut Out

BY E. C. PARHAM

When the load of a shunt-wound generator is increased, the voltage at the terminals of the generator decreases owing to the voltage drop caused by the resistance of the armature brushes and connecting wires. In order to maintain the original terminal voltage, it is necessary to cut resistance out of the field rheostat, thereby increasing the current through the field winding. Where a machine has a properly adjusted compound winding, it will not be necessary to disturb the shunt-field rheostat as the load increases, because the load current passing through the series turns supplies the necessary magnetism increase, which would otherwise have to be supplied by increasing the shunt-field current. If a machine is compounded to maintain constant voltage at its terminals, it is evident that the shunt-field current will be less than it would be if the series turns were omitted and the voltage maintained by hand regulation of the shunt-field rheostat.

In many instances operators have complained of the heating of generator-field coils, and the heating has been found to be due to the series winding having been cut out. In one instance it was cut out because it was grounded and the machine was operating on a grounded circuit. In another case it was cut out because the series-field shunt was loose, thereby causing the machine to over-compound. In a third instance, where a compound-wound exciter was used for exciting the field of a synchronous motor, the operator had cut out the series winding because he liked hand regulation better.

In all these cases the heating was eliminated by restoring the compound winding. As pointed out in the foregoing, if a generator is designed for compound regulation, the current in the shunt winding need not be of so high a value as that of the corresponding shunt machine. Therefore it follows that if the series turns of such a machine be discarded and all regulation be effected by means of the shunt winding, the shunt-field current must be greater at full load, and therefore the shunt winding will heat more than it ordinarily would.

Materials of Steam-Boiler Construction

By A. J. DIXON

Main facts concerning different grades of steel used for boiler making. Effects of carbon, phosphorus, sulphur, silicon and manganese. Chemical and physical properties required and methods of testing to determine the fitness of the steel for boiler use.

YEARS ago copper was largely used for the firebox sheets and stay-bolts in boilers of the locomotive type, while the flues consisted of brass tubing. The ductile and flexible properties of copper, as well as its ample tenacity and high heat conductivity, and its ability to resist the corrosive action of furnace gases, caused it to be regarded as the ideal material for the purposes mentioned. For nearly all other requirements of boiler making at that time the staple material was a high grade of wrought iron produced by the reduction of pig iron with wood charcoal alone used as fuel. This charcoal iron, so called, is practically free from the impurities resulting from the combustion of coke and similar fuels in the blast furnace.

Copper fireboxes and stays have long since gone out of use. In recent years wrought iron has given place to the low-carbon or mild steels; in fact steel is now the only material specified for shells, drums and fireboxes in all first-class boiler design, its use being required by law in many localities.

The grades of steel used in boiler making are distinguishable from the best grades of wrought iron only in their physical characteristics. Chemically, low-carbon steel and charcoal iron are virtually the same. The main difference between the two metals is the homogeneous structure of steel as compared with the laminated and fibrous texture of wrought iron, due to the different methods of manufacture.

Making Wrought-Iron Plate

In the making of wrought iron the puddling process leaves the metal in the condition of a soft plastic ball saturated with slag. This ball is taken from the furnace and dropped into a machine which squeezes out most of the slag. It is then passed through a train of rolls which ejects much of the remaining slag and gives the plastic mass the form of a bar. This muck-bar, as it is called, is cut up into strips; enough strips to produce a sheet of the desired size are bound into a bundle, the bundle is then brought to a welding heat and passed through the rolls.

Thus it is that a wrought-iron plate consists of a series of welds. This accounts for its laminar structure. The presence of slag in the material contributes largely to its fibrous texture, the rolls drawing the metal out into a stringy mass, each fiber of iron being, in fact, the core of a slender thread of slag.

In the manufacture of mild steel the metal comes from the furnace in a liquid state and is run into ingots. Since it has only a trace of the essential properties of genuine steel, this material has been termed ingot iron.

The first essential of boiler plate is a uniform blending of the physical properties that will enable the material to recover from the strains induced by the various stresses of operation. The most important of these properties is tenacity, or ability to resist a pulling stress. Carbon is the ingredient that gives this property. Carbon possesses no great strength on its own account, but when joined in chemical affinity with iron it develops strength therein. Correct proportions must be maintained, however. Increasing the carbon content up to a certain per cent. conduces to strength; beyond this point the strength deteriorates. Mild steel that contains 0.1 per cent. of carbon, for example, has a tensile strength of about 50,000 lb. per sq.in. while 12 times this quantity, or 1.2 per cent., increases the tenacity to nearly 140,000 lb. per sq.in., which is probably the limit for carbon steel. Increasing the percentage of carbon above this figure causes a proportionate drop in the tenacity of the steel. With 2 per cent., its strength is about 90,000 lb. A further gradual increase of the carbon component causes the material to rapidly acquire the characteristics of cast iron.

Hardness Desirable In Boiler Plate

Carbon also contributes to the hardness of boiler plate. This quality is especially desirable in flues and tubes and the sheets of fireboxes and combustion chambers, where the metal must withstand the abrading action of cinder-laden gas current. There is, however, a degree of hardness beyond which it is impossible to go without sacrificing other very necessary qualities of good boiler plate. Enough carbon to give a high degree of hardness would, for example, diminish the ductility of the material or the property which permits it to be drawn out or elongated. Its malleability or the property by which it adapts itself to change of shape by hammering, bending or rolling, might also be impaired to a ruinous extent. Likewise the plate would be lacking in toughness; enough carbon to make it quite hard would also make it brittle.

Good boiler steel contains just enough carbon to insure proper melting in the furnace. This consideration amply gages the amount necessary to produce a satisfactory blending of the properties enumerated. Generally, the quantity of carbon is considerably less than 0.25 per cent. This practically removes all liability of the material to harden and crack under stress caused by a sudden and wide change of temperature.

Openhearth Process of Steel Making

The laws of some states require that mild steel for boiler making be made by the openhearth process. In this process either of two methods are employed, known as the basic method and the acid method. These terms refer to the chemical reactions taking place in the furnace elemental substances of either an alkaline or an acid nature in the lining of the furnace and in the slag being the determining factors in the reactions. The acid method is more simple than the basic method,

inasmuch as it removes none of the phosphorus and sulphur from the charge of pig iron. The quantity of these impurities is, therefore, greater in the product of the acid hearth. Hence the basic method is preferred in the manufacture of boiler steel.

Besides the chemical elements already mentioned (carbon, phosphorus and sulphur) there are two others (silicon and manganese) that combine with iron in the composition of steel boiler plate. Excepting carbon, without which iron would be of little commercial value, these elements are present in mild steel principally because the expense of getting rid of them prohibits the attempt.

Sulphur is detrimental in various ways, its effect being mostly to impair the tenacity and ductility of the plate, especially when hot.

Phosphorus enhances the strength of steel. It also adds to the hardness of the plate and thus makes it better able to resist abrasion. These qualities are, however, best secured through the medium of carbon, because phosphorus tends to make the material brittle. Steel containing much phosphorus is particularly weak against shocks and vibratory strains. On this account it may be considered the most harmful impurity in steel boiler plate.

The small quantity of silicon present in boiler plate tends to make the steel slightly harder than it would otherwise be, but apparently without diminishing its toughness or ductility, and also without appreciably affecting its tensile strength. This element might, therefore, be regarded as a beneficial ingredient.

Effect of Manganese in Steel

Manganese is a hardening agent. Steel containing a considerable proportion of this element acquires a peculiar brittleness and hardness that makes it difficult to cut. Manganese has, however, a neutralizing effect on sulphur. It combines with the sulphur in the steel to form manganese-sulphide. This compound is less objectionable than the iron-sulphide that would otherwise be formed. The presence of manganese may, therefore, be regarded as advantageous. To insure a complete union with the sulphur, however, the quantity of manganese must be at least four times greater, since the affinity between these elements is comparatively weak.

The standard rules of boiler design require the physical and chemical properties of the grades of steel used for plates, stays and rivets to conform to certain uniform specifications. Plates that require staying or flanging, for example, as the sheets of fireboxes and combustion chambers and the heads of cylindrical shells, and also plates exposed directly to the gases of combustion, must not contain more than 0.04 per cent. of phosphorus nor more than 0.04 per cent. of sulphur. Shell plates not directly exposed to the fire or gases of combustion may not have more than 0.05 of either phosphorus or sulphur. The percentage of manganese is left to the discretion of the steel maker.

The tensile strength of flange steel and of steel intended for the shell plates of externally fired boilers must be between 55,000 and 65,000 lb.; of firebox and rivet steel, from 55,000 to 63,000 lb.; and of shell-plate steel for internally fired boilers, from 65,000 to 70,000 lb. In the tensile test a bar having a cross-sectional area of one square inch is stretched in a testing machine until it pulls apart. The force exerted at the instant of rupture measures the ultimate tenacity of the material. During this test the elasticity and ductility of the steel are also determined.

Elastic Limit or Yield Point

In any substance there is a limit beyond which the material cannot be strained without producing a permanent change of shape; this is called the elastic limit or yield point of the material. In the case of boiler steel it is generally required that the yield point shall not be less than one-half the tensile strength. Firebox steel, for example, that has a tensile strength of 56,000 lb., should retain its elasticity until the testing machine records a pull of 28,000 lb. When released from a less tension than this, the bar should return to its original length. The snap and vigor shown in this action is an indication of the resilience or spring-like quality of the material. The specifications require that stay-bolt steel shall have an elastic limit not less than 0.5 the t.s. and a tensile strength not less than 50,000 lb. Stay-bolts made of charcoal iron must have a tensile strength of at least 49,000 per sq.in. and an elastic limit not less than 29,400 pounds or 0.6 the t.s.

When the tensile stress exceeds the elastic limit, the bar becomes permanently lengthened. If the bar is of very soft steel, it may stretch to almost double its original length before breaking. This elongation of the material is a measure of its ductility and is expressed as a percentage of the original length of the test piece, which is commonly taken as eight inches. Thus, the rules require that shell-plate steel shall have an elongation not less than 24 per cent., flange steel not less than 27 per cent., and firebox and rivet steel not less than 30 per cent. in excess of an original length of eight inches.

Bending Test Determines the Malleability

The bending test determines the malleability of the steel. This is the most exacting of all the tests to which boiler steel is subjected. A specimen one-half inch thick must show no trace of fracture when bent double upon itself and hammered down to close contact while cold. This is called the "cold test." A similar specimen is given the same treatment after being heated to a cherry red and quenched in water at a temperature of from 80 to 90 deg. F. This is called the "quench test" and is intended to show if the metal has the hardening character of genuine steel, which, very evidently, would render it dangerous as a boiler material.

In the making of mild steel, small cavities are apt to be formed by gas bubbles in the molten ingot. Seams may also be found in the finished product, either on account of incomplete welding or separate strata of the metal or of slag getting between the strata. These defects are particularly objectionable in steel intended for shells and drums and butt straps. The tensile stresses in these parts, and in fact in stayed flat sheets as well, demand that the steel be as nearly homogenous as it is practicable to make it, while a less degree of homogeneity may be permitted for rivet steel. The test for flaws of the kind mentioned is to nick the specimen with a chisel so that it may be held

in a vise and broken with a hammer. Examination of the fracture should reveal no seam more than one-fourth inch long.

In the design of boiler shells the compressive or crushing stresses in the section of metal between the edge of the sheet and the rivet holes must be given consideration. The molecules of the metal oppose greater resistance to compression than to tension. Mild steel has a compressive strength of about 95,000 lb. per square inch.

The prime requisite of good rivet steel is malleability. The comparatively low percentage of carbon in this class of steel insures this quality, but it also reduces the ability of the metal to resist shearing and tensile stresses. Tension in the rivets of a boiler is, however, relatively unimportant, while the cross-section of the rivets can readily be made large enough to give ample strength against shear. Rivet steel should have a shearing strength of at least 44,000 lb. per sq.in. in single shear, and 88,000 lb. in double shear, or when cut through simultaneously in two separate planes of cross-section.

Much cast iron was used in boiler making at one time. The plain cylinder boilers of long ago usually had cast-iron heads. Sectional boilers also were built of cast iron, while the tubes of water-tube boilers were formerly expanded into cast-iron headers. Its use in this class of work, however, has been restricted chiefly to the making of boiler mountings and supports, hand-hole plates and manheads. Cast steel, which is generally stronger and more homogeneous in texture than cast iron, is now largely used for these purposes, but the best practice calls for stamped or forged steel.

Cast iron is a dangerous material to use where high steam pressures are concerned, chiefly because it is impossible to know the internal condition of a casting from the appearance externally. Large slag holes and cavities made by gas bubbles may be hidden under an apparently sound exterior surface; also there may be severe local strains in the grain of the metal on account of unequal cooling in the mold. Even when the castings are sound, there is still the danger of sudden cracking from stresses caused by the extreme variations of temperature prevailing in the generation of steam.

The only thing about cast iron to recommend it as boiler material is its practical imperviousness to ordinary corroding elements. This property renders it peculiarly adapted for use in the making of mud drums, Until recent years it was so used in the leading types of water-tube boilers. The mud drums of these boilers are now made of cast or wrought steel.

The Electrical Study Course—Inductance

How an electromotive force may be induced in one conductor in close proximity to another carrying an electric current, or in the conductor itself through which the current is passing, is explained. The former is known as mutual inductance; the latter, self inductance.

WE HAVE already learned that when an electric current flows through a conductor, the former causes a magnetic field to be set up about the latter. This magnetic field takes the form of concentric circles, as shown in Figs. 1 and 2. The direction of the magnetic field is determined by the direction of the current. The cross in the center of the conductor indicates that the current is assumed to be flowing away from the reader, and for this direction of current the magnetic field revolves in the direction indicated by the arrowheads. If the direction of the current is reversed, as in Fig. 2, the direction of the magnetic field is reversed, as shown.

This magnetic field seems to emanate from the center of the conductor and has an increasing diameter as the current increases. Fig. 3, *a*, *b*, *c* and *d*, illustrates the idea. At *a* is represented the effect that would be obtained with a small current flowing in the conductor; at *b*, *c* and *d* the successive developments of the magnetic field as the current increases. When the current decreases in value, the reverse effect is true; that is, the magnetic field will die down, as illustrated by *d*, *c*, *b* and *a*, Fig. 3. This increasing and decreasing diameter of the magnetic field about a conductor as the current increases or decreases in value creates an electromotive force in the conductor itself and other conducting material in close proximity to the former. In the last lesson we found out that an electromotive force was produced in a conductor by moving it across a magnetic field, or when the magnetic field was moved so that the conductor cut across the lines of force. This latter effect is the one that interests us in this lesson.

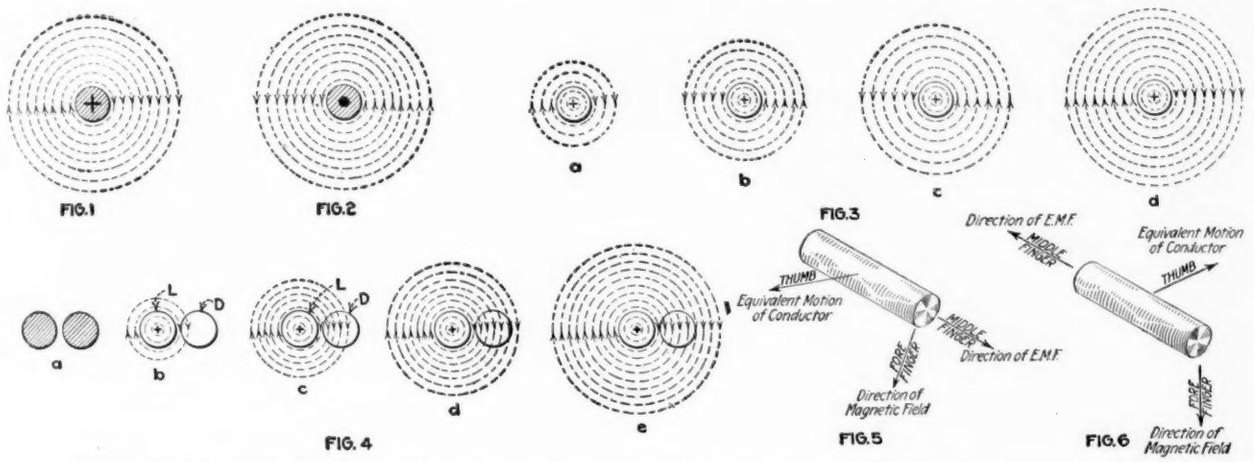
Consider two conductors placed close to each other, as in Fig. 4, *b*, with a current flowing through one of them as indicated by the cross. As the current increases in value, the diameter of the magnetic field also increases, until the current reaches a normal value, as illustrated by *b*, *c*, *d* and *e*. The magnetic field of the live conductor *L* is expanding to the right by the dead conductor *D*. This is equivalent to moving conductor *D* to the left across the magnetic field of conductor *L*, which gives the conditions for generating an electromotive force; namely, a conductor cutting a magnetic field.

The next thing to consider is the direction of the electromotive force developed in conductor *D*. This is illustrated in Fig. 5. It has already been seen that the magnetic field of conductor *L* expands in a right-hand direction by conductor *D*, which is equivalent to moving the conductor in a left-hand direction, as indicated in Fig. 5; also that the lines of force are in a downward direction. Then by applying the right-hand rule for the direction of the electromotive force in conductor *D*, Fig. 4, it will be seen that the fingers will point as indicated in Fig. 5, and the direction of the electromotive force produced in *D* is opposite to that applied to *L*.

One thing to remember is that a voltage is produced in *D* only as long as the current is changing in value

in L; as soon as the current reaches a constant value the lines of force also reach a constant value, cease expanding and are therefore no longer cut by conductor D, although conductor D is in the magnetic field when the current has reached a constant value, there is no relative motion of the former across the latter. There is, however, a motion of the lines of force downward by conductor D, but this is only equivalent to moving the conductor upward parallel with the lines of force and therefore does not cut the magnetic field, but simply moves in it; consequently no voltage is generated.

from the center of the conductor and expand outward. If this is true, it is at once evident that the conductor cuts the lines of force as they expand from the center to the outside of the wire. On the right-hand side of conductor L, Fig. 4, b to e, the lines of force are expanding in a right-hand direction, which would be equivalent to moving the conductor to the left. In other words, conductor L is cutting the lines of force in the same direction, just as a second conductor in close proximity to L, as already explained. Since the foregoing is true, the wire carrying the current will have



FIGS. 1 TO 6. ILLUSTRATING SELF AND MUTUAL INDUCTANCE AND DIRECTION OF INDUCED VOLTAGE

If the current in L is caused to decrease, then the circles of the magnetic field will decrease in diameter, and this will produce a left-hand direction of the magnetic line in reference to conductor D. That is, if e is the original condition and the current decreases to zero, a Fig. 4, will show the condition when the current has ceased to flow. From e to a the lines of force have been contracting in a left-hand direction past conductor D. This would be equivalent to moving the conductor in a right-hand direction across the magnetic field. The equivalent condition is shown in Fig. 6, and by applying the rule for determining the direction of the voltage when the direction of the lines of force and equivalent direction of the conductor are known, the voltage produced in D when the current in L is decreasing, will be seen to be in the same direction as that in L, as indicated in Fig. 6.

What we have just seen is that when the current is increasing in conductor L, it produces a voltage in conductor D opposite to that in L, and when the current is decreasing in L, it produces a voltage in D having the same direction as that in L. This voltage is produced by what is called "mutual inductance," and the voltage is said to be induced in D by "mutual inductance." This is the principle of the induction coil and alternating-current transformer. What has been shown is that two coils with no electrical connection between them may have a voltage and current set up in one by passing a current that is changing in value through the other. When direct current is used, the current is varied in value by breaking and making the circuit.

Another thing to consider is the effect of the magnetic field on the conductor itself. It has already been pointed out that the lines of force seem to emanate

an electromotive force induced in it in the same direction as a second conductor in close proximity to the first, and from what has been shown in Figs. 5 and 6 the direction of this voltage is opposite to the applied electromotive force when the current is increasing in value and in the same direction as the applied electromotive force when the current is decreasing in value. Or in other words, this voltage induced in the conductor carrying the current opposes any change in the value of the current. The voltage induced in the conductor is said to be produced by "self-inductance" and, like

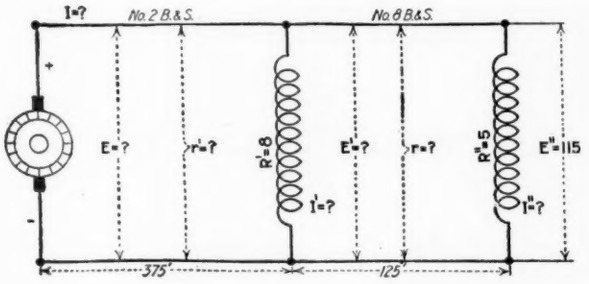


FIG. 7. COMPLEX CIRCUIT

mutual inductance, can take place only when the magnetic field is changing in value. The effects of mutual and self-inductance enter into electrical problems under a great many conditions, as will be seen in future lessons, therefore it is important that the principle explained in the foregoing be firmly fixed in the mind. In future lessons other examples will be given of where an electromotive force is produced by a conductor cutting the lines of magnetic force.

In the study problem given in the last lesson the armature of the dynamo had a resistance of 0.0175 ohm and was connected through 1250 ft., total length, of 250,000-cir.mil. conductor to a load that had 1.13 ohms resistance, and supplied 225 amperes.

From the wire table the resistance of 1000 ft. of 250,000-cir.mil. conductor is 0.042 ohm; then the resistance of 1250 ft. is $0.042 \times 1250 \div 1000 = 0.0525$. The total resistance R of the circuit is the sum of the armature, line and load ohms, or $R = 0.0175 + 0.0525 + 1.13 = 1.2$ ohms. Total volts E generated in the armature to cause a current of $I = 225$ amperes to flow through a resistance $R = 1.2$ ohms is $E = RI = 1.2 \times 225 = 270$ volts. This voltage is divided into three parts: That to cause the current to flow through the armature, that to overcome the line resistance, and that available at the load. We have learned in previous lessons that the volts across any section of the circuit is equal to the resistance of the section times the current flowing through it; thus the volts drop E_g in the armature is equal to the armature resistance times the current, or $E_g = 0.0175 \times 225 = 3.9375$; E_d, volts drop in the line, equals line resistance times the current, or $0.0525 \times 225 = 11.8125$; E_a, the available volts at the load, equals the load resistance times the current $= 1.13 \times 225 = 254.25$; and the total volts $E = E_g + E_d + E_a = 3.9375 + 11.8125 + 254.25 = 270$, which checks up with the value previously obtained.

The watts loss W_g in the armature is equal to the volts drop in the armature times the current, or $W_g = E_gI = 3.9375 \times 225 = 885.9375$; watts loss Wl in the line equals volts drop in the line times the current, from which $Wl = E_dI = 11.8125 \times 225 = 2657.8125$; W_a, the watts supplied to the load, equals the available volts times the current; that is $W_a = E_aI = 254.25 \times 225 = 57{,}206.25$; and the total watts $W = W_g + Wl + W_a = 885.9375 + 2657.8125 + 57{,}206.25 = 60{,}750$. The total watts W also equal the total volts E times the total current I, or $W = EI = 270 \times 225 = 60{,}750$ watts.

In Fig. 7 the size and length of the conductors are given, r and r' represent the resistance of the two conductors that the arrowhead points to. Find the values indicated by the interrogation marks, also the total resistance of the circuit.

The Refrigerating Troubleman on the Job

By E. W. Miller

The engineer in a packing house was having considerable trouble with the ammonia disappearing from the receiver during the day. During the forenoon the receiver was full, but in the afternoon the ammonia would gradually disappear until the frost on the expansion valves on some of the coils would thaw off, and these valves would begin to sputter like a leaky air valve on a radiator. It was peculiar that the machine would invariably begin to freeze at the same time, although it would be generally expected that it would warm up whenever the charge ran short. Toward morning the liquid would gradually accumulate in the receiver again until that vessel was entirely full.

The engineer at first considered charging more ammonia into the system, but he had recently put in a heavy charge and it would fill up part of the condenser during the morning, when the receiver was full, and increase the head pressure to a dangerous point. Being unable to solve the puzzle, the engineer called on me. We went over the system without finding anything wrong. The condenser was investigated for dead coils and thoroughly purged without affecting the trouble in the least.

I was as badly puzzled as the engineer. After considering the problem from all angles, I decided to watch the proceedings for the eutire day to see if I could get an inkling of the trouble. The next day I was on the job early in the forenoon. There were six coolers in the plant, two large chillrooms, one large storage cooler, one offal cooler and two large freezers. At this time the chillrooms were heavily loaded with fresh beef every day, and what was not immediately disposed of was put in the storage cooler every morning. The offal cooler was also worked to its utmost. Every room was heavily piped, so there was no trouble in maintaining the temperatures as long as there was a sufficient supply of ammonia.

Few Coils Working

To take care of the heavy run of killing, it was the practice of the operators to turn on every coil in the chillrooms and the offal cooler in the early afternoon when these rooms began to get filled. The valves to the coils in the storage cooler were turned on full in the morning when the chilled beef from the two rooms was put into it. As the temperature in the rooms came down during the night, some of the coils were cut out until toward morning probably less than half of them would be working, and on these the feed, of course, had to be considerably reduced as the temperatures came down.

Owing to the shortage of ammonia at a time when the load was heaviest, it was difficult at times to get the meat properly chilled before morning. The chillrooms had been worked even harder without trouble than at this time. The temperature of the chillrooms seldom got above 45 deg. when fully loaded, while during the present period they had gone up to 55 deg. several times.

The Trouble-Man Perplexed

During my day at the plant everything went along nicely until about 2 p.m. At this time we went up and turned on the coils in the chillrooms that had not already been turned on, and the coils in the offal cooler. We also "shook up" the expansion valves all around. When we got back to the engine room, the liqud level in the receiver had dropped a little, but it was still nearly full. From then on it began to go down gradually until toward 6 p.m. it was about all gone. About half an hour later the frost began to come off the expansion valves on many of the coils and they would begin to sputter, and at the same time the machine began to get considerably colder. This, and the fact that there was a plentiful supply of ammonia for a long time after we had set the expansion valves, the setting of which was never changed until late in the night, made the problem still more perplexing. That the coils were

getting all they could handle during the greater part of the afternoon was evidenced by the temperature of the suction gas and the even frosting of the suction valves on all the coils. If there had not been enough ammonia to go around, as I at first assumed, the ammonia should have disappeared shortly after all the coils had been turned on and were working at maximum capacity. Instead, it required about four hours for it to slowly disappear. It was this and the freezing up of the machine that had puzzled the engineer, and it had me stumped.

The night engineer had come on duty in the meanwhile, and I went home. After supper, while going over the details in my mind in an effort to find a solution, two things that I had so far failed to pay any attention to came to mind. One of them was that the suction pressure had gone up from 17 lb. in the forenoon to about 25 lb. in the evening, when the cooler temperatures were at the maximum and the coils were working at full capacity. This was to be expected. The other was a chance remark by the night engineer about the difficulty of keeping the freezer temperatures down in the early part of the evening. This put me on the track of the solution.

Conditions Become Better

The next day I got on the job a little after noon. The ammonia began to disappear as usual when all the coils were turned on. When the receiver was about half empty, I shut off all the coils. The receiver gradually filled up again until it was about three-quarters full, where the liquid level remained stationary for the rest of the afternoon. The machine ran at an even temperature, and the coolers never got above 45 deg., although they had an unusually heavy load that day.

When the night engineer came in, I told him not to turn on the freezer coils until the suction pressure came down to at least 22 lb. and preferably lower. If the liquid began to disappear to any great extent after they were turned on, he was to cut them out again until the suction pressure dropped a little more. The cooler temperatures came down a good deal more rapidly this evening on account of the plentiful supply of ammonia, and with it the suction pressure, so that he was able to cut in the freezer coils about 10 o'clock. At the same time there was less variation of the freezer temperatures than there had been on previous evenings.

Carried the Temperature Too Low

The whole trouble came from the freezers; these were held at a temperature of about 10 deg. They were heavily piped, and the coils were connected for bottom feed. When the suction pressure came up to about 23 lb., the temperature of the ammonia in the freezer coils was the same as that of the rooms and consequently no ammonia was boiled away, and whatever was fed into the coils, as well as that which was already there, remained until the suction pressure came down below this point. When the suction pressure went up to 25 lb., the freezer coils acted as condensers and heaters as the temperature and boiling point of the ammonia in the coils was about two degrees higher than that of the rooms themselves. With the feed at the bottom and the outlet at the top, the ammonia gradually accumulated in the coils until the shorter ones, at least, filled up. With the feed still on, the quantity fed in crowded out an equal quantity at the top, which escaped into the suction line and, coming back, froze up the compressor. The freezers were lightly worked at this time, and as a consequence the expansion valves were barely cracked. For this reason the coils slowly filled, and when the suction pressure came down so that the temperature of the ammonia was below that of the room, it gradually boiled out again until toward morning they were probably nearly empty and remained so until the pressure began to increase again during the day.

A new superintendent was primarily the cause of the trouble. Originally the freezers had been held at 20 deg., but the new superintendent, for reasons best known to himself, had insisted on reducing the temperature to 10 deg. This went well as long as the other rooms were not worked hard and the suction pressure never went above 19 to 20 lb.; but when a heavy rush came on and the suction pressure went up to 24 or 25 lb., it put the freezer coils out of commission as far as cooling was concerned, and the ammonia accumulated in them as fast as fed in, until the suction pressure came down low enough so that they resumed normal action. When informed of the trouble, the superintendent compromised on a temperature of 15 deg. for the freezers, and in addition, when there was an unusually heavy load on the chillrooms and the suction pressure was unusually high, the freezers were shut off for three or four hours during the heaviest pull, and no further trouble was experienced.

He, Too, Is Serving

The oiler who watches the bearings or the workman who drills rivet holes all day long in the machine shop sometimes pauses to say to himself: "Why can't I be in the thick of it? Why should other men no more patriotic than I in the trenches and near them, have all the big moments and the thrills, while I go through the same meaningless drudgery day after day?" They may not phrase it thus, but such is the protest in the back of their heads. They should get rid of that delusion. For every man who mixes with his daily stunt the desire to make it useful in winning the war is in his way a soldier. Remember what Daudet tells of the artisan and his finished handiwork:

> Among the two thousand workmen of the town there was perhaps not one who had not aided in the great work according to his skill and his strength. But they had worked in isolation, each one by himself, groping his way. . . . And now they saw their machine, standing before them, complete, all its parts fitted together. And proud they were of it! In a moment they surrounded it, saluting it with joyous laughter and triumphant cries. They admired it as connoisseurs, stroked it with their rough hands, caressed it, talked to it in their own rude dialect: "Well, old girl, how goes it?" The founders pointed to the enormous screws of bronze, saying: "We cast them!" The smiths replied: "But it was we who worked the iron, and mixed it with the drops of our sweat." And the braziers and riveters, not without justice, sang the praises of the huge boiler coated with red lead like a fighting elephant. If these boasted of the metal work itself, the engineers, designers and fitters prided themselves just as much upon the form the whole had taken.

Even translation does not kill the spirit of this, the spirit that Kipling voiced in "The Ship That Found Herself"—that the humblest rivet in the machine is as mighty as the whole machine. Our workers at home are the rivets of the machine in the trenches.—*Collier's Weekly.*

Capitalized Value of One-Tenth of an Inch of Vacuum

By C. H. BAKER
Mechanical Engineer, Public Service Electric Co., Newark, N. J.

Formulas and charts are given for calculating the capital that may be economically invested in condenser equipment for each one-tenth of an inch of vacuum gained with steam turbines. Problems are also worked out to show the application of the charts.

THE capitalized value of vacuum improvement in a turbine power plant is a desirable factor when the designing engineer wishes to know what additional money can be spent for improving the vacuum by installing a larger condenser; also when the operating engineer desires to know the amount of money he can spend annually for condenser cleaning to improve the vacuum.

If the designing or operating engineer can improve the vacuum one-tenth of an inch of mercury, the saving will be approximately one-tenth of a pound of steam per kilowatt-hour at full load. Then with steam costing 18c. per 1000 lb., a load factor of 75 per cent. and fixed charges of 17 per cent., the capitalized saving per year will be $696 for 1000-kw. load, or $13,920 for a 20,000-kw. turbine. In other words, $13,920 can be spent for enlarging the condenser to obtain 0.1 in. improvement in vacuum, or for the same improvement the same amount can be spent per annum for condenser cleaning.

For steam saving at other than full or most economical load, the chart, Fig. 2, shows the gain in pounds per kilowatt-hour, per 0.1-in. of vacuum improvement, between the vacuum range of 28 to 29 in. of mercury. This curve represents a fair average for the most recent turbine designs. Let

D = Capitalized saving in dollars;

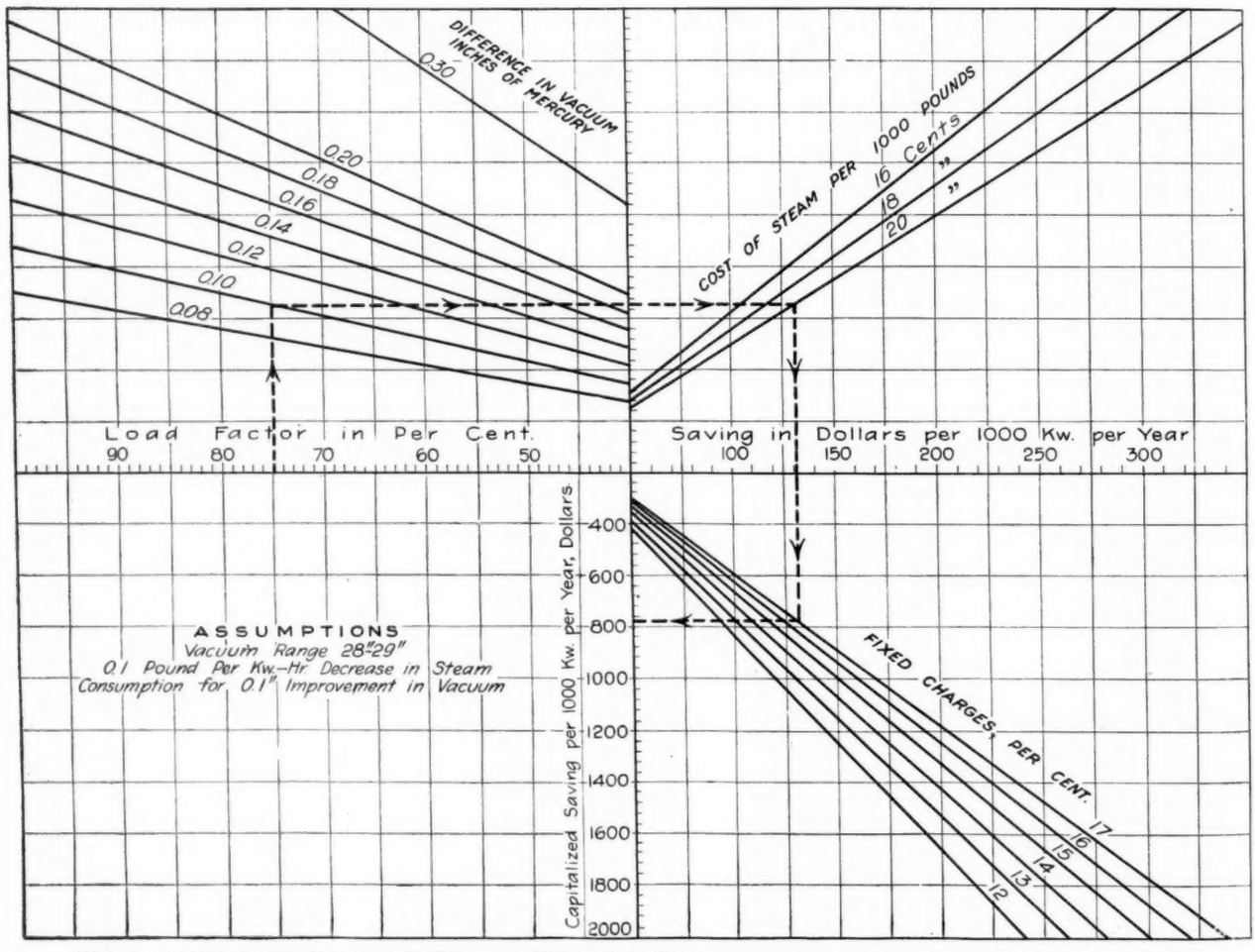


FIG. 1. CAPITALIZED-VALUE CHART OF DIFFERENCE IN VACUUM FOR 1000-KW. GENERATING CAPACITY

I = Improvement in water rate, pounds per kilowatt-hour;
K = Turbine normal rating, kilowatt;
L = Load factor of turbine in per cent.;
F = Fixed charges in per cent.;
C = Cost of 1000 lb. of steam in cents;

H = Hours per year 365 days = 8760 hours.

Value of I may be obtained from the chart, Fig. 2; value of F may be assumed to be 17 per cent., allowing 10 per cent. for amortization, 6 per cent. for interest and 1 per cent. for taxes.

Then the pounds of steam saved per year $= \frac{LIHK}{100}$ and dollars saved per year $= \frac{LIHKC}{100{,}000}$. The capitalized saving $D = \frac{LIHKC}{1000F}$. If K = 1000 kw., then $D = \frac{LIHC}{F}$.

The chart, Fig. 1, showing the capitalized value of vacuum improvement, was developed from this formula for 1000-kw. generating capacity, allowing a decrease in steam consumption of 0.1 lb. per kw.-hr. for 0.1 in. improvement in vacuum.

For loads other than full, also for vacuum improvements other than 0.1 in. of mercury, the capitalized saving may readily be interpolated from this chart.

Given a turbine to operate at 20,000-kw., its most economical load, with a yearly load factor of 75 per cent., with steam costing 20c. per 1000 lb., what amount can be spent to increase the vacuum 0.1 in., assuming

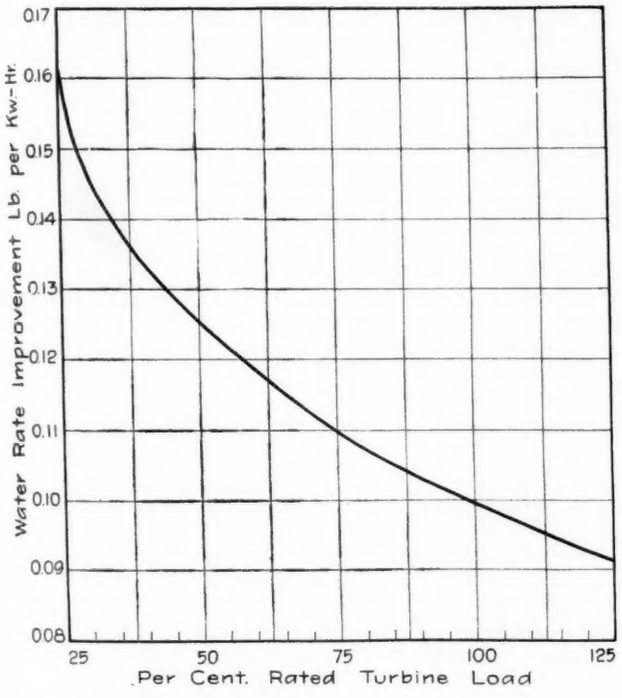


FIG. 2. WATER-RATE IMPROVEMENT ON TURBINE DUE TO 0.1 IN. INCREASE IN VACUUM

17 per cent. fixed charges and a water rate of 0.1 lb. improvement per 0.1 in. increase in vacuum?

Note on the chart, Fig. 1, 75 per cent. load factor in upper left-hand quadrant, read up to 0.1 in. line, then horizontally to 20c. line in second quadrant as indicated by the dotted line in the direction of the arrows, then down, noting $131.50 saved per year, to 17 per cent. line, then horizontally note $775 capitalized saving per year per 1000 kw. Then for 20,000-kw. capacity the capitalized saving would be $775 × 20 = $15,500, which is the amount that could be spent for a larger condenser to improve the vacuum one-tenth of an inch.

Where the cost of producing steam is not known in capitalizing vacuum, but the price and heat value of the fuel is known, the chart, Fig. 3, may be used in arriving quickly at a close value of cost of steam production. Seventy per cent. boiler and furnace efficiency is a good figure for a modern plant.

Given fuel of 14,000 B.t.u. per lb. and costing $4.10 per ton (2240 lb.), also $4.50 per ton, assume 70 per cent.

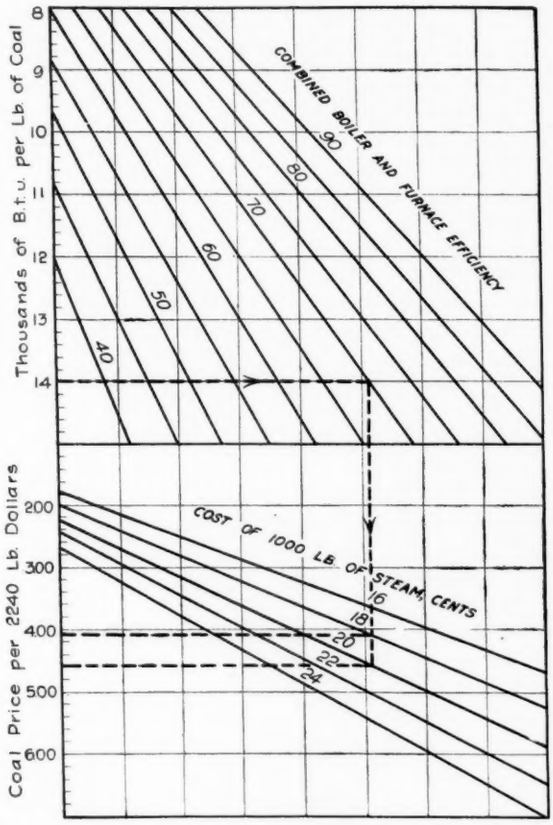


FIG. 3. COST OF EVAPORATING 1000 LB. OF WATER FROM AND AT 212 DEG. F.

boiler and furnace efficiency, to determine cost of steam per 1000 lb., neglecting labor and maintenance.

Note 14,000 B.t.u. in the upper half of the chart, read across to the 70 per cent. efficiency line, then down as indicated by the dotted line in the direction of the arrows, then note cost of fuel on the lower half of the chart and read to the right to the intersection of the vertical line, which is found for coal costing $4.10 to be at the 18c. per 1000-lb. line and for coal costing $4.50 to intersect at the 20c. line.

Senator George H. Ellis, of Newton, member of subcommittee on fuel of Massachusetts Public Safety Committee, says the shortage of bituminous coal in New England on Jan. 1, 1918, will be 6,603,017 tons and that the shortage will have to be met by importation to the port of Boston of 6,000,000 tons of anthracite. Receipts of anthracite have advanced 10 per cent. over last year, but this increase has been consumed by industries that had to use hard coal in place of their usual receipts of bituminous.

Meeting the Emergency

By E. W. MILLER

How two engineers acted when the same kind of an accident happened. One lost his head, thus shutting down the plant, the other did the right thing and kept most of the plant running.

IT IS when emergencies arise and the unexpected happens that the good judgment, presence of mind and thorough grasp of details of the exceptional man reveal themselves. The average man gives little thought to what he should do in certain emergencies, but waits until the thing actually happens and then does the wrong thing first, making matters still worse. On the contrary, the forehanded man considers possible eventualities and figures out as nearly as possible what to do when the emergency arises.

An incident that occurred recently in a large power-plant illustrates the actions of the average man. The generating equipment consisted of one 1500- and two 500-hp. units. At the time of the accident the three were operating in parallel. The larger unit was rather unmanageable except when fully loaded, and if the load was reduced below a certain point it would run away. For this reason a speed-limit device had been installed.

The first indication of trouble was a cloud of smoke on the crankpin side of the engine. The crank was incased in a sheet-iron housing, and when the cover was removed a cloud of smoke rolled out. Hot babbitt flew in all directions, and in a few moments the crank began to pound like a trip-hammer.

Melted Crankpin Boxes

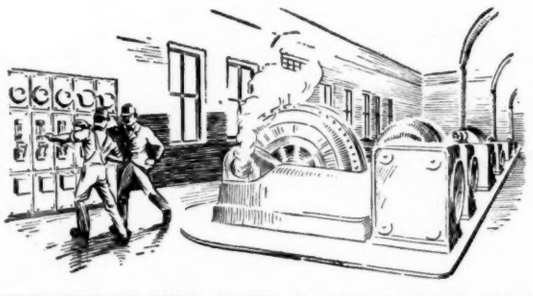
There was no question about what had happened; the babbitt in the crankpin boxes was about gone. As soon as the engineer in charge found what was the matter, he "lost his head," ran to the switchboard and tripped the circuit-breaker on this machine. Then pandemonium broke loose. The disabled engine speeded up at a terrific rate, but the speed limit saved the day. This was tripped by an electrical device, but the valve operated by steam and in so doing it released a considerable volume of steam at boiler pressure. This was discharged into the oil pan under the engine cylinders, and it let go with a hair-raising racket and blew the oil and water in the pan all over the place.

Tripping the circuit-breaker on this unit threw the entire load on the two smaller ones, which had about all they could carry before, and the circuit-breakers on these came out with a bang together with a display of fireworks both at the breakers and around the commutators of the generators, shutting down the entire generating equipment of the plant. It required about half an hour to get the smaller units going again with all the load they could carry, and most of the departments had to remain idle all this time.

The same thing happened to the crankpin several months later, but there was a new man on the job. He had evidently given a little thought to what he would do in case something of this kind happened, because when the oiler ran for the breaker to repeat the previous performance, the engineer grabbed him and prevented him from doing so. He realized that the babbitt in the crankpin bearings was beyond redemption already, and he stationed the oiler at the throttle of the engine with strict orders to do just what he was told to do and no more. Previously he had conferred with the chief regarding which circuits to cut out in case it became necessary, and he calmly started to open these circuits, at the same time having the oiler throttle the engine as the load came off. When the load was reduced to the point where the two smaller units could handle it, he had the oiler shut the throttle and at the same time he tripped the circuit-breaker.

In this way some of the most important departments never knew that there had been trouble and they were able to continue operations without interruption. An extra pair of brasses had been provided for just such an emergency, and about three hours later the big unit was again carrying its load. The second time a large number of the plant officials never knew that anything had happened, while in the first accident every member of the plant force that could crowd into the engine room was on the scene. The second man had considered the problem and knew just what he was going to do.

A parallel incident happened recently in a motor-driven ice plant. The transmission line from the central station, as they all do once in a while, would trip out, often momentarily, but long enough to make the relays operate and trip the circuit-breakers of the machines. This would also trip and close an automatic valve in the suction line, shutting off the suction line to the machines. The general procedure of the operators had been to shut off the liquid line to the ice tanks the first thing, next to shift the starting controller to the starting position, then to open the bypasses on the compressors and reset the automatic valve in the suction line. By this time the machines had generally been stopped for some time.



PREVENTING THE OILER FROM TRIPPING THE CIRCUIT-BREAKER

A new engineer had been hired, and one day when the manager happened in the plant the circuit-breakers came out on account of transmission-line troubles. Like a flash the new engineer jumped for the controllers and swung them to the off position, closed the breakers again, set the brushes on the motors for starting, swung the controllers of both motors on, until both ammeters showed that the motors were taking the allowable excess load, and then the automatic suction valve was

yanked open. The entire operation required only a fraction of a minute; in fact, the machines had slowed down but very little so that he was able to throw in all but the last point on the starting controller when the current was on again. The motors were of the wound-rotor induction type which necessitated the setting of the brushes of the collector rings for starting; if they had been direct-current motors, he would have made still better time.

The manager stood around in open-mouthed astonishment while the engineer cleared the trouble. He was still more surprised when the latter informed him that this was his first experience in a motor-driven plant. Upon being further questioned by the manager as to where he had acquired such amazing dexterity in handling trouble, he said that when starting to work in the plant, he had cataloged every possible contingency that he could think of and then laid out the best line to follow to get out of the trouble. Interruption of the current supply he knew he could expect at any time, and he had gone over all details as to the best possible method of clearing the emergency and analyzed every move until he had determined the quickest way and gone over it in his mind until it was practically instinct with him to do the right thing. As a result he never hesitated about what he was to do at any part of the operation.

This is in line with the best practice in some of the largest central-station systems in the country. The men are coached regularly in what to do in emergencies and have to pass examinations every once in a while on the subject. Therefore they are never at a loss to know what to do when the emergency arises.

Errors in Electrical Measuring Instruments Due to Static

By R. K. Long

In the care and handling of portable electrical instruments attention is frequently directed against rubbing the glass front of the meter before taking readings, because of the possibility of causing an error in the indication. Almost everyone is familiar with the fact that if a glass rod is rubbed on a piece of cloth and then made to touch small pieces of paper, the latter will adhere to the former. This is what is known as frictional electricity and is due to the friction between a dry cloth and an insulating material.

Practically the same thing happens when the glass front of the meter is rubbed with a dry cloth or piece of waste—the glass becomes charged with static, or frictional, electricity. The glass may hold the charge for quite a long time in meters mounted on a switchboard panel or in portable instruments mounted on a base of dry varnished wood, both these being good insulators and holding the electrical charge from leaking to earth. Meters may be so electrified on a dry day that the pointer will move from zero to near full scale deflection by simply rubbing a dry cloth quickly and but once across the glass.

Obviously, a static error due to rubbing the glass with a dry cloth may enter into the reading of instruments if precautions are not followed. One such case came to the author's attention where the man reading the meter was waiting for voltage to come on a long high-tension transmission line for test purposes. While waiting for the meter to indicate that the line was alive, the attendant wiped some dirt off the meter. Up went the needle to almost full scale deflection, indicating considerably more than the amount expected. As waterwheel-type generators were being put into service at the other end of the line, and as the pressure suddenly appeared far too high, the power house was immediately telephoned to disconnect the generators, and in this way it was found that energy had not been cut in on the line.

In important work, as with line-loss determination, taking of oscillograms, etc., it is often advisable to make sure that the meter cover is not electrically charged before or even during taking a reading. There are several ways of removing this static, or frictional, electricity from the glass cover over the meter's dial. The glass holds this charge only when the air is dry. In damp locations rubbing a meter will possibly only cause the pointer to give a slight kick, whereas, in a hot, dry plant it will swing almost across the scale. The reason is that in the former case the high moisture content in the air allows the charge to escape, whereas in the latter case the dry air prevents leakage of the charge.

Eliminating the Static Charge

If, after having cleaned the glass front of the instrument with a dry cloth, the attendant blows his breath over the surface of the glass, the charge will disappear. The explanation is that the moisture in the breath condenses on the glass and fills the air in close proximity with the meter with moisture, which enables the charge to leak away.

Another way to accomplish this same result, although it may not be quite so effective as the foregoing, is to place the hand on the glass, as this also offers a leakage path for the charge of electricity. The uncertainty in doing this is that the hand may be dry instead of moist.

Another way to prevent electrical-instrument errors due to a static charge on the glass is, after wiping the glass, to pass a lighted match over and about an inch and a half from the glass. After the match has been moved across and back again near the glass surface, the charge will have disappeared and the moving element of the meter will be seen to go back to zero if there is no potential on the instrument. Do not rub the glass of a meter before reading it if an accurate indication is required. To prevent errors it is a good practice to get the habit of breathing on the glass without taking a reading.

Chemical analyses show the high degree of purity attained by the Bureau of Standards in the preparation of relatively large amounts of the following materials, all of American manufacture, samples of which are to be distributed to determine fixed points of the temperature scale for calibrating pyrometers: Zinc, 99.993 per cent. pure; tin, 99.988; copper, 99.987; aluminum, 99.68.

In one hundred feet of a 6 x 37 wire cable there are more square feet of surface requiring lubrication than in a 35,000-hp. twin tandem reversing engine, one of the largest engines of its kind in the world.

Globe-Johnston Air Pump

There have always been difficulties with reciprocating air pumps in the production of high vacua, and it is to overcome these that the Globe-Johnston rotary valveless air pump has been invented. It is supplied by the Globe Pneumatic Engineering Co., Ltd., 1 Victoria St., London, S.W.1.

Fig. 1 is a section of this pump and shows clearly its construction and action. It is applicable to every

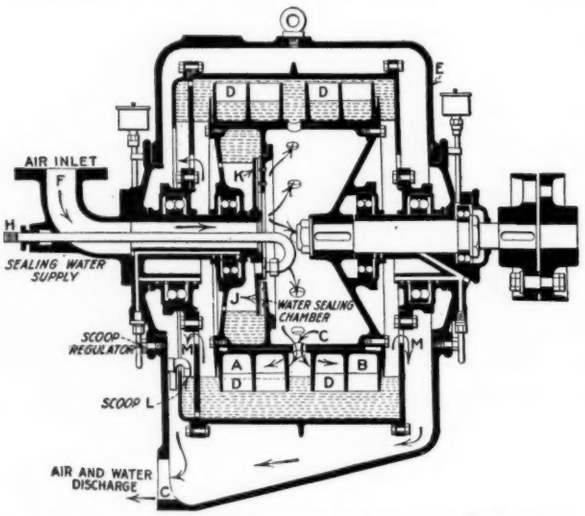


FIG. 1. GLOBE-JOHNSTON ROTARY VACUUM PUMP

process where vacuum or low-pressure compressed air is required.

The minimum capacity for which the smallest size is built is about 20 cu.ft. per min., and the various sizes are graded upward so that the largest machines cover the highest capacities used in industrial processes. The speed of rotation ranges from about 3000 r.p.m. for the smallest sizes down to about 1000 r.p.m. for the largest. The pump can operate with any type of condensing apparatus, and in connection with these plants will produce under favorable conditions a vacuum within one-half inch of the barometric reading.

As an air and gas compressor or blower, the machine is applicable to all processes where low-pressure air is required.

According to the *Steamship*, this rotary vacuum pump and compressor consists of two main parts, the rotor and the drum. These parts rotate on ball-bearings. The modification necessary to convert the vacuum pump into an air compressor is slight, but a reversal of certain component parts or of the direction of rotation is necessary. The difference in arrangement between vacuum pump and compressor will be seen on reference to Figs. 2 and 3. Its construction is shown in the accompanying illustrations.

The rotor, shown in Figs. 2 and 3, is a hollow member on the outer circumference of which deep double-thread screws are formed. Fig. 2 shows the arrangement of the rotor for the vacuum pump and Fig. 3 for the compressor. In the smaller machine these threads are single-handed only, but in the larger sizes right and left double threads are employed in order to obviate the possibility of end thrust. A passage C runs between the twin-screw threads *A* and *B* into the interior of the rotor. When the machine is producing a vacuum, this passage acts as the inlet to the screw threads, but when air is being compressed it is the outlet. Similarly, the pipe *F*, running from the interior of the rotor to the exterior of the machine, is the inlet pipe in the vacuum pump and the outlet pipe in the compressor. The screw threads are joined by a large number of narrow partitions, or blades, *D* which are equally spaced round the periphery of the rotor. The outer and inner edges of these blades are respectively flush with the top of the screw threads and halfway down the depth of the threads, Figs. 2 and 3.

The ring of water is, in the first place, set up by the action of these blades in conjunction with centrifugal force. Annular rings *E*, called shrouding plates, fitted to the sides of the rotor and reaching somewhat below the water level on the discharge side, prevent the exhausted or compressed air returning along the screws when the thread ends leave the water seal. The rotor is coupled direct to the driving shaft.

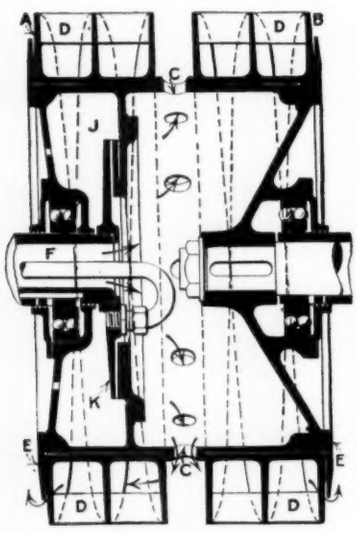


FIG. 2. ROTOR FOR VACUUM PUMP

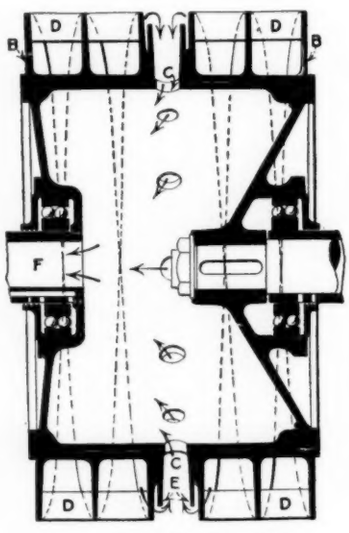


FIG. 3. ROTOR FOR COMPRESSOR

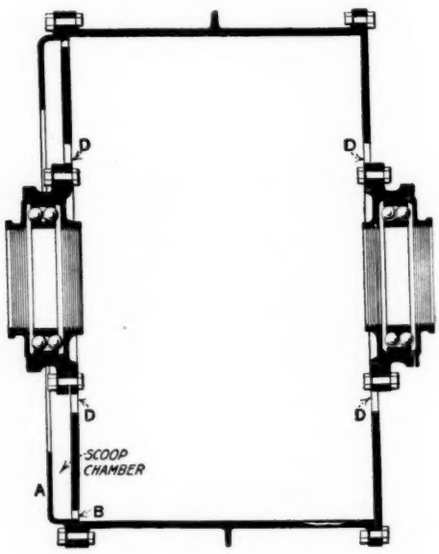


FIG. 4. ROTATING DRUM

The rotating drum, Fig. 4, is a hollow cylinder also running on ball bearings. The holes *D* in the side plates of the drum act as discharge and inlet openings for vacuum pump and compressor respectively. The drum, when rotating, contains the "ring of water" and is set eccentrically to the rotor. The relative eccentricity of the rotor and the water ring produces what is called the working space, as shown in Fig. 5. The net circular area of this space considered in conjunction with the pitch of the screw threads and the speed of rotation is the measure of the air capacity of the pump.

At one end of the drum a ring *A*, Fig. 4, is fitted, forming a channel communicating with the drum through the holes *B*. The scoop, the function of which is described later on, is a suitably formed piece of tubing fixed into the wall of the casing, having its working end dipping into the previously described channel and pointing in a direction opposite to that of the rotation of the drum. It is shown at *L*, Fig. 1. In vacuum pumps where the load is practically constant very little adjustment of this scoop is required, but means are provided for changing its position by hand. In air compressors this adjustment can be made automatic, and an effective means of adapting the output of air to varying demands is thus provided. As the demand is reduced and the pressure, in the receiver or pipe system tends to rise, the automatic control gear causes the scoop to lower the depth of the ring of water until compression ceases. In these circumstances the power consumption is reduced to about 15 per cent. of that required at full load, with a corresponding reduction in the running costs. As the pressure falls the scoop is automatically returned to its working position, whereupon the water rises to the required depth and compression begins again.

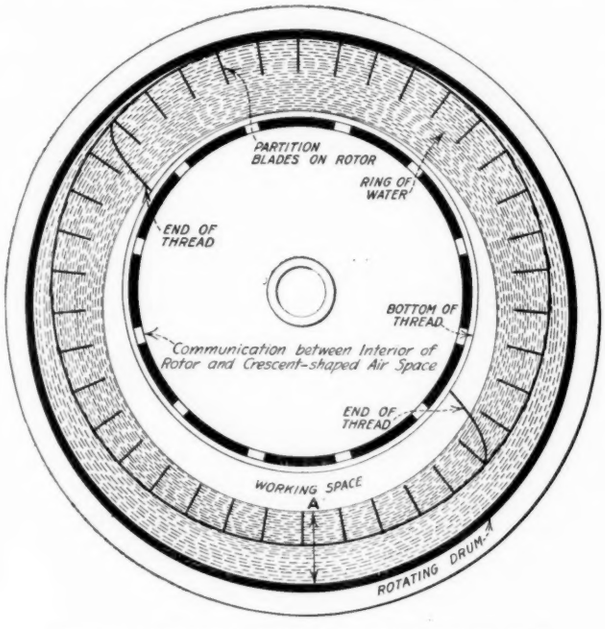


FIG. 5. SECTION SHOWING RING OF WATER

The casing *E*, Fig. 1, is a cast-iron or steel structure with the upper cover removable to facilitate examination or the dismantling of the machine. The rotor and drum rotate on ball bearings in this casing. The aperture *F* is the induction pipe, and the opening *G* the air and water discharge pipe in a vacuum pump. The casing and rotating parts form a self-contained unit which may be mounted on a bedplate, brackets, concrete or any other suitable foundation.

The essential feature of the pump is a rotating screw, set eccentric to and working in conjunction with a ring of water established and maintained by centrifugal force within a container called, in the following description, the "Drum." To put the machine into operation water is allowed to flow through the pipe *H*, Fig. 1, and the pump is set in motion. The water passes through the water-sealing chamber *J*, to the interior of the drum, which it gradually fills until it becomes deep enough to be caught by the partition blades *D* of the revolving screw rotors *A* and *B*. It is then whirled round the interior of the rotating drum *C* by these blades.

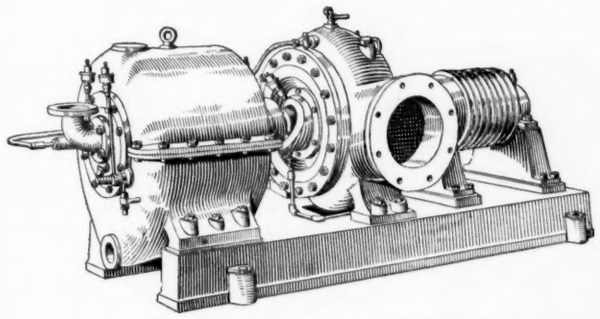


FIG. 6. GLOBE-JOHNSTON ROTARY CONDENSING PLANT FOR MULTIPLE-JET CONDENSERS

The friction between the whirling water and the drum causes the latter to revolve also, and in a very short time the drum and the rotor are running at practically the same speed. The sealing water continues to flow into the machine until a ring of water is formed within the drum sufficiently deep to submerge the screw threads on the rotor at the point where, owing to the eccentricity, they approach nearest to the inner periphery of the drum. It is this water, maintained in the form of a ring within the drum by centrifugal force operating in connection with the threaded rotor set eccentric to it, that produces the pumping effect. Immediately the ring of water has reached the proper depth, the pumping action begins. The position of the ring of water in relation to the rest of the rotating system is shown in Fig. 5. The friction referred to obviously ceases when the two parts have acquired the same speed.

The time occupied between the first revolution and the moment when pumping begins varies according to the size of the machine. With machines of the largest capacity it is only a matter of a few minutes.

During the operation of the pump a small stream of water flows continuously into the drum through the pipe *H*, Fig. 1, and in order to maintain the correct depth in the ring of water, a scoop *L* is fitted. The scoop skims off the surplus water, and this function is continuous while the pump is working. The water may be conducted from the scoop back to the supply tank and be used over and over after being cooled.

The water seal is merely a substitute for a stuffing-box. It consists of a fixed disk *K*, Fig. 1, around which a chamber containing water rotates. An equal water

level on each side of the disk is maintained by the centrifugal force in the water. If, however, atmospheric or other pressure exists on one side of the disk and not on the other, it is obvious that this level will be disturbed and the water will rise higher on the side opposite to that on which the pressure is exerted. A new point of balance will thus be found wherein the combined pressure and centrifugal effect on the one side will be equal the centrifugal effect only on the other. If at this point the periphery of the disk is sufficiently submerged, it is clear that no leakage of air can take place from one side to the other. Being so arranged as to receive automatically a continuous supply of water, the water seal requires no attention to keep it tight.

Flow of Water in Pipes

By E. W. Greene

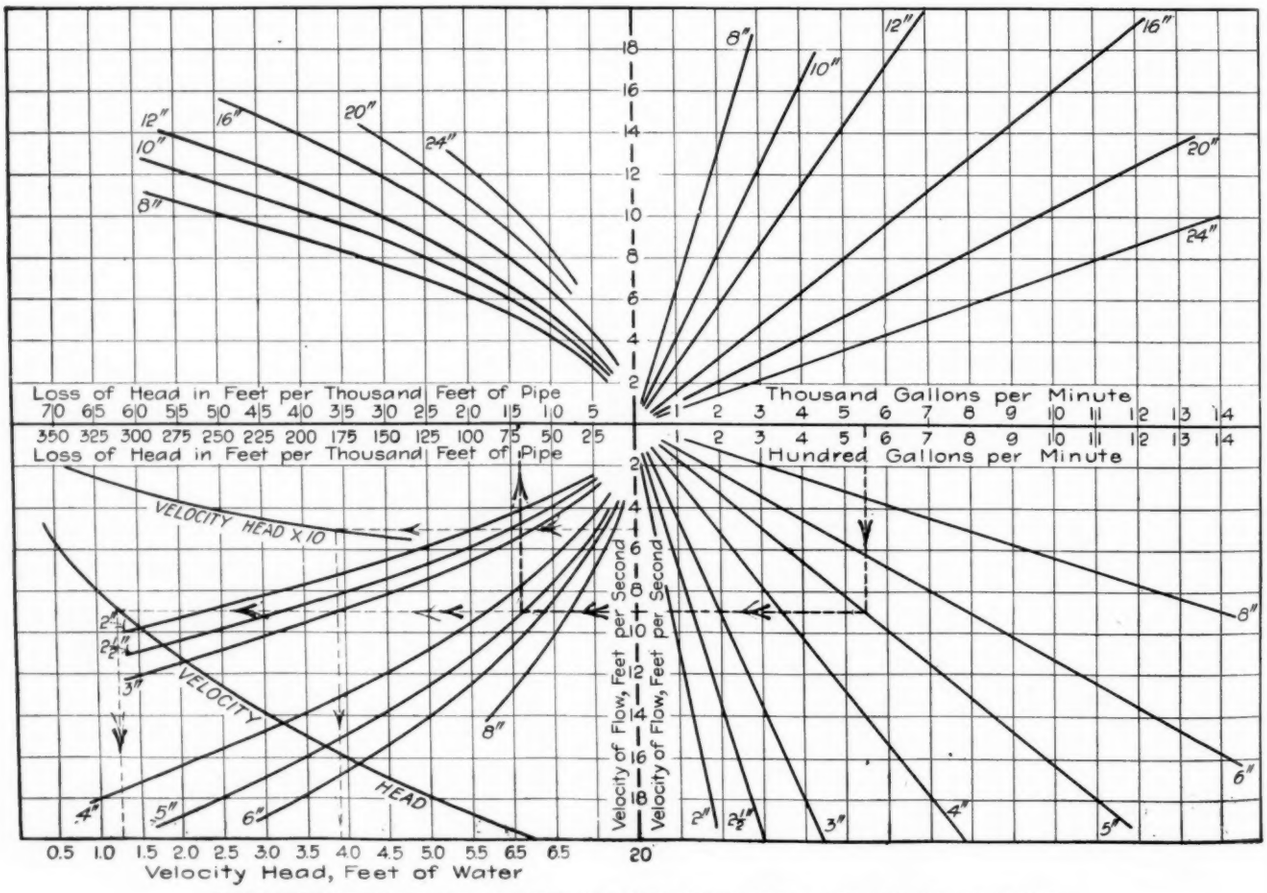
The graphic chart shown herewith has been prepared to serve as a ready notebook reference when neither hydraulic tables nor a hydraulic slide rule is available. The values for the loss of head in feet per thousand feet of pipe were obtained from the Hazen & Williams formula (see Hazen & Williams Hydraulic Tables) using a constant of 120 for the smaller pipe sizes and 100 for the larger. The velocity of flow can be read directly for any condition, also the velocity head in feet of water.

As an example of the use of the chart, let it be required to find the loss of head due to the friction of water flowing at the rate of 550 gal. per min. through 150 ft. of 5-in. cast-iron pipe, without bends. Follow the vertical line from 550 gal. per min. downward to its intersection with the 5-in. pipe-size line, read horizontally to the velocity of flow, which is 9 ft. per sec.; continue horizontally to the 5-in. pipe-size curve, then read vertically upward to the loss of head, which is shown to be approximately 70 ft. of water per thousand feet of pipe. The loss of head is directly proportional to the length of pipe; therefore,

$$\frac{150}{1000} \times 70 = 10.5 \textit{ ft. loss of head (friction loss)}$$

The velocity head for these conditions is found by reading horizontally from the velocity of flow, 9 ft. per sec., to the "velocity head" curve, then vertically downward to 1.25 ft. of water.

The curve "velocity head $\times$ 10" is useful in determining the velocity heads for relatively low velocities, where it is difficult to read the values on the direct scale. For example, let it be required to find the velocity head for a flow of 5 ft. per sec. Follow the horizontal line from 5 ft. per sec. (velocity) to the curve "velocity head $\times$ 10, then follow vertically downward to 3.9 ft. of water on the scale, then $\frac{3.9}{10} = 0.39$, which is the true velocity head in feet of water.



VELOCITY OF FLOW, VELOCITY HEAD AND LOSS OF HEAD OF WATER IN PIPES

The chart deals only with straight pipe, and the additional loss of head due to bends and valves must be added. There is nothing original claimed in the preparation of this chart, but it may prove useful to some readers of *Power*.

Editorials

Profiteering

A GREAT city is in flames. In a cataclysm of fury the conflagration reaches out its blazing arms and spreads its fiery shroud over the fleeing victims. The products of lifetimes of toil and saving suffice to feed it for but minutes, and each scorching breath licks out a shrieking human torch.

A band of gallant men brave the perils of the falling walls, the exploding stores, the stifling smoke and singeing gas, to hold the holocaust in check.

What if the holders of the coal necessary to supply the pumps and fire engines should combine in a demand for extortionate prices, claiming that their community's need was a God given opportunity to recoup their years of meager profit?

What if the water company, in view of the increased cost of labor and fuel, of the excessive demand upon and rapid diminution of the water supply, should announce that a doubling up of the rates would be necessary to encourage it to go on producing the water necessary to keep up the fight?

What if the distributers of food should take advantage of the disorganization and shortage to hoard their stores, control the incoming supplies and dole them out at the highest price which the necessities of the people would compel them to pay?

What if the firemen, the carters of coal, the workers for the water and transportation and electric and gas and telephone companies, and all the agencies necessary to the continued efficient, fighting of the fire and the subsistence of the population, exasperated by the diminished purchasing power of their day's work or incited by those whose lust for loot or revenge or personal advantage was served by the failure to put the conflagration down, should go upon a strike?

The world is aflame. All of these iniquities and more are being practiced upon an unprecedented scale. The Government fixes prices far and away above those which yield a fair profit in ordinary times, and producers whine that it is discouraging production. Profiteers declaim against the unholy tampering with the sacred law of supply and demand and claim that the only way to conserve the supply is to allow them to charge so much for it that one can scarcely afford to use it. People and papers that support and defend the invisible empire of hundreds of trade and industrial princes, dukes and barons, inveigh against a single "czar" appointed by the people to assert, autocratically if need be, in their name, their right to the products of their toil at cost plus a fair profit. The Government beseeches economy in the use of fuel, and the Great White Ways of hundreds of cities blaze back to the noonday sun its radiant energy. Government experts make a canvass of the food supply and urge the necessity of its careful and restricted use, that we and our allies may not be incapacitated or hampered by the lack of sustenance, and we throng the lobster palaces, make no or immaterial changes in our home tables, go on eating and drinking as though there were no war and make the earnest efforts of those who do appreciate the gravity of the situation and seek to impress it upon others the subject of quips and jests. The Government points out the growing deficiency of man power and urges the utmost economy in the use of everything that it takes man power to supply—and that includes about everything there is in the way of commodities and service—and is met with the "business as usual" remonstrance of the man who is afraid that general economy and retrenchment will ruin his trade.

Every indication points to the probability that this is to be a long war. We shall be called upon to make sacrifices of which we little thought when we went into it. To the end of putting down this fiery attempt at world domination and of making the Twentieth Century forever memorable in the history of the world as having demonstrated the futility of striving for supremacy by force of arms; to bring about the replacement of force by jurisprudence in the settlement of international disputes and the eternal banishment of war, we are prepared to suffer deprivations of pleasure, of comfort, of all but the necessities. But let not the burdens of the people be increased to swell the fortunes of those who make their country's need the occasion of their personal profit.

War's Effect on the Bureau of Mines

LEGALLY, the Bureau of Mines is consulting engineer to Uncle Sam only. It can assist the industries only indirectly. This it has done in excellent fashion for many years. Its researches into the utilization of fuels, particularly as related to steam making, have been of value to the industries; to what extent it is perhaps impossible to estimate, but surely they have been of considerable value. As an example of its promotion of the efficient burning of coal, two bulletins issued by the Bureau and dealing with hand-firing of soft coal have been sent to over 70,000 persons, each of whom requested them by letter. Information of the kind contained in these two bulletins alone, when so widely distributed to persons sufficiently interested to write for them, has done much to cut down the woeful avoidable waste of so vital a national resource—a vital resource because the coal industry, its production and consumption, is a basic industry.

While it is true that this is a time to apply what is already known about fuel economy, it is paramount that it is no time to stop research work in that field. When the dawn breaks and peace comes, we shall be convinced as never before, that it is as important to work and use efficiently in peace as it is in war.

The Bureau is losing many of its best men. The money the Government will pay them cannot hold them

against the inducements offered by the industries. It is accepted without question that the nation's woe is not an occasion for labor and capital to make money, as so well said by Sir Stevenson Kent, of the British Commission; but that argument neither logically nor remotely negates the truth that the laborer is worthy of his hire.

The industries, the Director of the Bureau, and our heavily burdened President should see to it that their influence is exerted to prevent further depletion of the highly skilled and the uniquely trained force of the Bureau of Mines. Here is a chance for the Secretary of War to promote the arts of peace and yet perform a high duty.

In recent years important projects for the conversion of coal into power at the mines have been completed. These plants have been designed to burn low grades of coal. The Hauto plant, Hauto, Penn., the new Warren Ridge, Ala., plant, and the new Windsor plant, Windsor, W. Va., are three examples of great pioneer work of this kind. Likely, similar projects will follow, though, unfortunately, in many localities the industries are too far removed from the coal fields to at this time warrant the investment necessary to transmit to them power generated at the mines.

Although the Bureau has done highly valuable work in assisting in the wide application of the efficient methods of fuel consumption and preparation for use, it should be borne in mind that this division of its work is but one of many. We would direct the attention of the Chamber of Commerce of the United States and the National Association of Manufacturers, also of the railroads and public-utility companies, to the need of voicing their disapproval of the depletion of the Bureau of its most valuable men.

The Nationalization of the American Society of Mechanical Engineers

ONE of the many good things that Dr. Ira N. Hollis has done, as president of the American Society of Mechanical Engineers, is the holding of the November meeting of the Council at Chicago. Council meetings have been held in connection with the spring gatherings in other cities than New York, but never before has the Council purposely gone to any other place than the society's headquarters for its deliberations. The effect has been splendid in quickened interest among the trustees and managers of the society's affairs, in inspiration and encouragement for the local section, and in an assuagement of the too-prevalent feeling that the society rests too heavily in and upon the headquarters in New York and is run in a preponderating measure by and for the engineers of the Eastern metropolis.

The advantages of being within easy visiting distance of headquarters are greatly overestimated. The headquarters is not a club, offers little encouragement to visitors without a definite errand, and the number of local members who do drop in is small compared with that of the visitors from other cities. This does not apply to the attendance at the monthly meetings of the local section, the only advantage connected with which is that they are held, not in the society headquarters, but in a room in the United Engineering Societies Building, the use of which is paid for in the same way as the rooms used by other local sections in other cities may be. New York members enjoy, in common with other New Yorkers, access to the Engineering Library maintained jointly by the Mechanical and other great national societies of engineers, but the resources of the library are available to the entire membership through a system of searching, photostating and copying, so effective and inexpensive that members even in New York find it more advantageous to avail themselves of it than to make their own searches. Everything is being done to emphasize the national character of the society and its interests and activities, and the effect of this departure will be helpful in this sense. We hope to see the practice continued.

Expedients To Avoid a Shutdown

ON ANOTHER page in this issue is a letter telling of what sometimes goes on behind the scenes—the efforts of a station crew to keep the plant going and all the circuits on. This case is typical and not at all unusual. Versatile operators will find means of overcoming difficulties that seem insurmountable. Bad coal, poor oil, overloaded machinery and a "thousand and one" other things will tax the capacity of the engineer and his staff to the limit at times. The attitude of the engineer under such trying circumstances is that of a fighter for an ideal. It would be much easier for him to drop a few circuits and drift along easily, and the chances are that he would "get by with it" for a while at least, but his ideal is *service*—not some of the time, but all the time.

It would be well for all who are dependent on the service of the engineer, in any capacity, to reflect that interruptions to such service are almost invariably the result of something really serious. When your lamps go out for a few minutes, it is likely to be a code message that some poor fellow is trying to make juice by burning dirt or having his own troubles of some other kind with a degenerate equipment. Don't swear; sympathize!

I. B. Zimman, head of the sales department of the Nebraska Power Company, believes, according to a newspaper item, that he has a better way to conserve coal than to reduce the number of illuminated signs. He states that the amount of coal used to illuminate them is comparatively small and suggests as an alternative that women refuse to wear the so-called French wooden-heeled shoes, as several machinery operations are necessary to make them. He believes that stopping the manufacture would save coal and that the heels are not necessary. It is easily seen that Mr. Zimman is not swayed by feminine propaganda.

Because of the success of high-speed air compressors and the development of suitable valves for high speeds, the high-speed ammonia (refrigerating) compressor was favorably received from the start. As an indication of how rapidly the application of this type of machine for refrigeration and ice-making is going on, the experience of the De La Vergne Machine Co. is illuminating. During the first half of its fiscal year, all machines sold have been of this type, not one slow-speed compressor having been ordered.

Correspondence

Expedients To Avoid a Shutdown

Power-plant work runs more or less in a groove as long as things are going right, but it is far from doing so when things go awry, and this usually happens when least expected. The following may be of interest in showing what can happen and to what extremes an engineer sometimes has to go to keep things moving.

During the week our night peak is of short duration, so it is quite safe to carry from 20 to 50 per cent. overload for the brief period, and this had been done with such clocklike regularity that it had become a routine. One night, however, the fireman came into the engine room and reported that with the poor lot of coal on hand it was impossible to keep the usual 175 lb. pressure with natural draft even before the peak came on. Forced-draft blowers had been installed on the 525-hp. boiler, a steam-driven blower on one side of the boiler and on the other side a belted motor-driven fan. So we decided to put these blowers on in an effort to get the steam pressure up where it belonged.

Our "sure enough" troubles then started. The 9-in. galvanized iron pipe leading from the fan to the boiler was a temporary affair, the lengths being simply stuck together with a little solder around the joints in some places. As soon as the fan had fairly started, one of the joints came apart, making it necessary to shut down the fan to fix it. By that time the steam pressure had dropped and the fire was in such shape that it was impossible to get the pressure up again to where it belonged. A hasty trip to the engine room showed that the peak was on and the engine was barely making speed. For three-quarters of an hour it was "nip and tuck." With both blowers on, the pressure could not be raised above 130 lb. As the fire got heavier, it became harder to hold even that, and slowly but surely it was going down. We had no other boiler that could be put on—one was being cleaned and the other being repaired—so it was a case of pulling through if possible.

When the pressure dropped to 115 lb. and a shutdown seemed inevitable, we decided that one of two things must be done—clean the fire or shake it down well. A thorough cleaning was not advisable, so I told the fireman to shake it down while I tried to relieve the load to some extent without pulling out any of the circuits. In the engine room things were in bad shape. The engine was "way below speed," and the governor weight arms were hitting the stops. I cut out the voltage regulator and dropped the voltage from 120 to 110 by means of the field rheostat. Naturally, there was a drop in the load and the engine again picked up speed. For a while I thought we would pull through without having to pull out any circuits, but it was inevitable that in cutting down the fire the steam pressure would drop temporarily at least. It went down to 100 lb. with the engine carrying about 85 per cent. of its capacity, and it again began to slow down. To avoid a total shutdown, I pulled out the street-light circuits, and the engine again picked up speed, even though it was still three-quarters loaded, but with only 100 lb. steam pressure. By this time the fireman had finished cutting down the fire and the pressure held and in a short time started to climb; so the street-light circuits were put on and the line voltage raised, and the regulator was put back on the line.

No one was censured as the affair was in a way unavoidable, but since then we have always kept another boiler ready to put on when necessary.

Middletown, N. Y. THOMAS M. GRAY.

Dye Works and Central Station Power

The editorial on "Dye Works and Central-Station Power" in the issue of *Power* for Nov. 20, 1917, is particularly interesting because it brings out the necessity of learning the whys and wherefores before final judgment is given. Certainly the fundamental principle of engineering is to first diagnose and then express an opinion.

But this editorial suggests a condition that might not be so readily uncovered and would remain puzzling to many an engineer who was not thoroughly familiar with dye-works operations. The history of dye-works plants seems to have been bound up with the use of the most inefficient and cheap forms of engines, based on the theory that the engine being a reducing valve, it made little difference as to how much steam per indicated horsepower per hour passed through the engine. In scores of cases small engines developing from 3 to 15 hp. have been and are today used to drive individual machines, the management believing this to be economical because the exhaust steam from the engines is used in the driven apparatus.

Casual observation of most of these plants will reveal a very considerable amount of exhaust steam being wasted either through an exhaust head or through the drain pipes from heating and drying apparatus, and no one is very much worried. To the engineer who starts out with the determination to account for every heat unit that was originally stored away in the coal, this condition proves to be about as bad as anything could be, and it doesn't take very deep thinking to show the reason why. In fact, it is so bad that in more than one instance it has been possible to purchase central-station power and show an actual saving.

An investigation of the facts will reveal the following, which is true of almost every dye works: Granting that heating and drying apparatus which is operated with individual engines and using exhaust steam from those engines presents a condition of apparent balance, it will be found that there is a great deal of apparatus which has to be driven that does not use steam, with the result that the exhaust steam from the main units is either wasted to the atmosphere or condensed in a condenser, the loss in either case being from 85 to 95 per cent. of

the heat. To look at it another way, the steam that is required in the drying apparatus can produce only enough power, when passed through an inefficient engine, to drive that individual machine, whereas, the same steam, if passed through an efficient unit, will drive not only the machine in question but several others.

If 10,000 lb. of steam per hour required for drying and heating purposes is developing only 200 hp.—and it will not develop any more than this in such engines as are frequently used—then more steam must be taken from the boilers to develop the remainder of the power, which is not accompanied by a use for the exhaust. On the other hand, if this 10,000 lb. of steam will develop 400 hp.—which it can easily do in an efficient unit—then not only will the 200 hp. required for the drying and heating apparatus be furnished, but there will be 200 hp. more for driving machines that do not use steam. Add to this the saving in cylinder condensation through the use of a single large unit as compared with a number of small units of an uneconomical type, the saving in cylinder oil, the saving in repairs and attendance, the saving in damages which are bound to arise through the use of leaky small engines, etc., and the net saving will be a return upon the investment far greater than the normal profits on the same amount of money invested in the business. The writer could cite case after case where the actual reduction in coal per unit of finished product paid for the cost of an efficient equipment in two years' time.

In an efficient dye works there will be a complete cycle with a minimum loss. The water evaporated from the boilers will pass through an efficient prime mover in the form of high-pressure steam, which will later be used in the form of low-pressure steam and will be returned in the form of condensation to the feed-water heater without loss, except the minor ones due to leaking stuffing-boxes and radiation. And a plant is not efficient until this condition has been established.

The great trouble is that the problem has been approached from the wrong end. The starting point should have been the minimum amount of low-pressure steam necessary to do the work, and to then produce the maximum mechanical power in the process of reducing this steam from high to low pressure.

There is probably no industry in the country which is so wasteful in the use of coal as the average dye works; and there are few textile industries in which the cost of coal per unit of product turned out is such a great percentage.

A certain plant of small dimensions is buying central-station power and saving money, because the amount of exhaust steam from its engine was so greatly in excess of the amount required that the net result was favorable to the central-station company. Under ordinary conditions, the answer would have been to install an efficient plant, but at present prices this was out of the question. This, however, is a rare case.

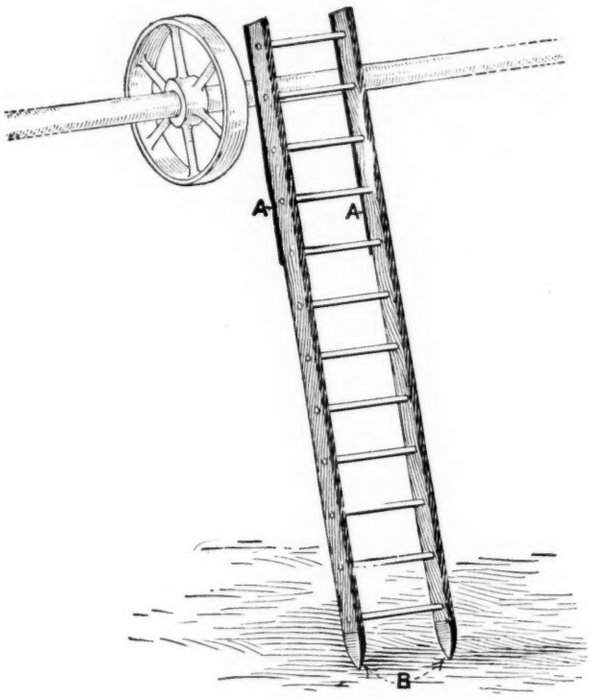
If there ever was a time when it was necessary to save coal, that time is now. Shifting the burden doesn't solve the problem. We are certainly not economically right until we have learned to turn out the finished product with the smallest expenditure of fuel as one item of expense, no matter where that fuel may be burned.

WARREN B. LEWIS.

Providence, R. I.

Safety Attachments on Ladders

Many accidents have occured to the men who inspect, oil and repair lineshafting, bearings, etc. It was observed in our plant that these were due chiefly to the fact that the ladder slipped when the man leaned too far to one side to reach a bearing for instance. To



LADDER MADE LESS LIABLE TO SLIP

prevent slipping along the shaft on which it was resting, rubber strips (marked *A* in the illustration) were tacked along both sides of the ladder. This plan worked out very satisfactorily, and no accidents have occurred since from this cause. The base of the ladder was also equipped with iron points at *B* to prevent slipping on the floor.

WILLIAM FORRAY.

Brooklyn, N. Y.

Chemistry and Progress

About a century and a quarter ago fanatics of the French Revolution preferred false charges against the celebrated Lavoisier, founder of modern chemistry, and his head was demanded. Before his execution he asked that his life might be spared long enough to enable him to complete some experiments he had under way, the result of which he thought might add to the sum of human knowledge. His petition was denied on the ground that the republic had no need of chemists. But since that fateful day chemistry has waged many a battle for recognition as a science of practical utility. Many years after his death Benjamin Franklin was dubbed a "soap boiler" and "chimney doctor." One of the first college laboratories for chemistry in this country was built fifteen feet below ground, presumably on the theory that it would not be amiss to locate in the bowels of the earth an institution that was to concern itself with such occult business. As late as

the middle of the last century objections were urged against chemists and other scientists holding an annual meeting within the precincts of Oxford University, England.

In contrast with this spirit of opposition it is estimated that more than 100,000 persons attended the National Exposition of Chemical Industries held in the Grand Central Palace, New York, during the week ended Sept. 20 last. Chemists and allied professional men to the number of 25,000 are said to have been in attendance. Three floors of the building were crowded with exhibits. The power-plant man who was fortunate enough to visit the exposition found much to enlist his interest and inform his mind—a chart, for example, showing the coal resources of Europe and the United States, according to which our Southern States possess more coal than all Europe combined. And the chemical engineer was there ready to talk B.t.u., flue gases, favorable and unfavorable furnace and boiler conditions, the scientific testing of coal values, the conservation of fuel, and other power problems hinging on chemistry.

Verily the "chimney doctor" is coming into his own. Twenty-five years ago to engage the service of a chemist to doctor a sick or out-of-condition power plant was hardly thought of. Today consulting chemical engineers are recognized as a necessity. It is demonstrated daily that competent professional advice pays here as it pays in other fields where the facts can be got at and rightly interpreted. The production of power is at bottom a scientific game, and the player always loses if he is ignorant of the rules. One of the secrets of Germany's remarkable show of efficiency in these dreadful days is to be found in the fact that for forty years she has sought diligently to learn the rules involved in every game of production and in every field of national endeavor. J. F. JONES.

New York City.

Only One Motor Operated

When direct-current generators that are driven from independent sources are operated in series, there is but little tendency to unequalize the loads. The governors maintain the prime-mover speeds within reasonable limits, and also beyond these limits the generator loads tend to equalize the prime-mover speeds; hence there is no cumulative effect tending to increase any slight inequalities that may occur. With motors the proposition is entirely different: Motors cannot be successfully operated in series unless their armatures are connected together mechanically or they are so small and easy running that the minimum running current is sufficient to keep either motor operating. Ordinarily, with motors connected in series without the armatures being mechanically connected, if either armature for any reason gets to running a little faster than the other, the slower one will finally stop and the other will race on account of the total voltage being applied across its terminals.

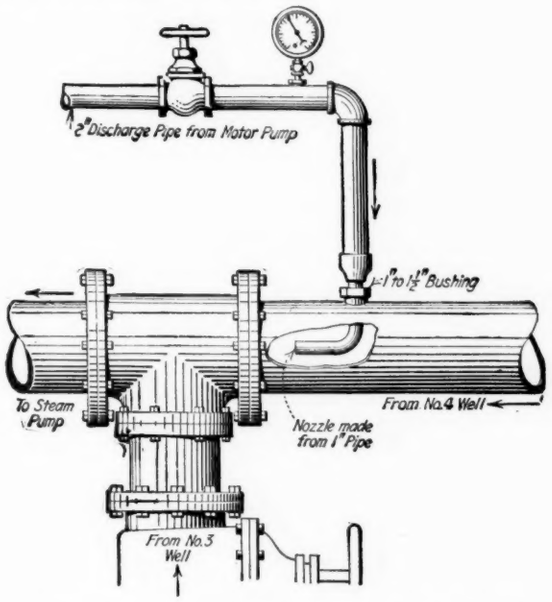
A large railway drawbridge was equipped with a motor-driven bell at each corner to warn whenever the draw was about to be opened. The connections were such that the bells would begin to ring the instant the circuit-breaker of the drawbridge motor was closed and would continue to ring until the gates and guards were in position. The bridge tender complained of erratic behavior of the bells; sometimes one bell would ring and sometimes another or perhaps two for a while, but never would the bells all ring together.

Investigation disclosed that the bell motors were connected in series; under this condition if one motor happened to be in a more favorable position for starting, it would start and race and the other would remain stationary. The layout proved to be entirely impracticable, and it was necessary to so modify it so that the motors were operated in parallel. E. C. PARHAM.

Brooklyn, N. Y.

Increasing the Water-Supply

The suction line to four shallow wells is about 450 ft. long, and I have difficulty in getting enough water during "New Mexico dry spells."



WATER JET CONNECTED INTO SUCTION PIPE

At No. 3 well we had an electric-driven triplex pump that was not working, so I connected its 2-in. discharge into the 8-in. main suction line in the manner shown in the illustration, making sort of a nozzle of pipe. My idea was to induce an increased flow from No. 4, which was farthest away, and to help out by whatever amount the triplex pump would put into the suction. The plan worked out first rate, and I get about 10 per cent. more water than before. V. O. SAFRANCK.

Fort Beyard, N M.

Gasket Fastened To Cover

This plan may help others who, in trying to put on a heavy manhole plate with the gasket and while centering it, find that the gasket moves every time it is nearly in the proper position and has to be replaced and a new try made.

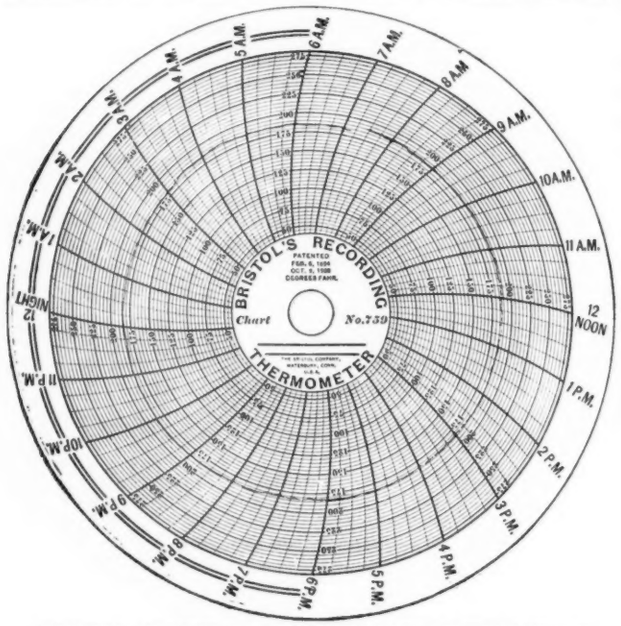
I drill and tap six holes close to the outer edge of the plate and put small screws through the gasket, two on each side and one on each end, so as not to rest on the gasket seat. The gasket is held there as if grown on the plate and never causes trouble by moving.

Brooklyn, N. Y. LOUIS NAPPA.

Operating Fuel Economizers

It is a mistake to feed economizers with too cold water. Sweating may not occur with the feed at 120 deg. F. or thereabouts, but it is better to run it at 150 to 190 deg. and have a recording thermometer to show whether it is kept there or not, and it should be made easy for the operating engineer to keep it steady. The chart shown was taken at random from our files. Since operating our economizers with the feed-water temperature as high as shown, we "don't know they are there."

We have a hot-water storage tank connected with the heater which has enough capacity to run the plant twenty minutes in case the supply should fail. The float in this tank, which controls the rate of flow to the heater, is adjusted to permit considerable variation in level in the tank before allowing a greatly increased flow through the heater, and the feed-water controllers on the boilers are adjusted to allow about six inches variation in the water level between light load and full load; that is, the water level tends to run about 6 in. lower with full load than when the load is light. In the plant where the chart was made, part of the steam from the auxiliaries is under the control of a thermostatically



TYPICAL CHART OF FEED-WATER TEMPERATURE

operated valve, and the chart was produced with no attention whatever from the operating force. The economizer tubes are clean, and soot does not stick to them. I think it is best to "forget" the fraction of a per cent. saving to be obtained by running the water colder and allow considerable margin on the high side to prevent external corrosion. Internal corrosion is then the only deteriorating factor and can usually be taken care of.

The matter of operating economizers under low pressure, then boosting the pressure up to that required to feed the boiler, appears to me to be a needless complication that will afford only temporary relief at most. The tubes of an economizer for 200 lb. boiler pressure are usually tested up to 1000 lb., and after assembling the unit should be tested to 350 lb. pressure. Why, then, reduce the working pressure from, say, 250 to 100 lb. per sq.in., and what is to be gained? I think other operating conditions have far more to do with the success of economizers than the pressure.

Midland, Mich. J. R. BELKNAP.

Preventable Accidents

Regarding the accident described by Mr. Lucas in the issue of Oct. 2, page 470, while it is bad practice to have keys exposed in this way, if the engineer's blouse had been buttoned, as clothes should be worn where there is revolving machinery, I believe the accident would not have happened. I think the proper dress for an engineer, or one working in a power plant, is overalls and jumper, with the overalls buttoned over the jumper and the suspenders worn over the jumper, making sure the sides of the overalls are buttoned and that no handkerchief or piece of waste is sticking out of the pockets. In this way there is little chance of getting caught unless the man gets right against the machine. I have known of pieces of waste or a corner of a handkerchief being caught in machinery and stopping the machine. It pays to be careful, always, around a power plant.

Another precaution that should be taken is in regard to the shoes. Men working in a plant do not know when they may step upon a hot coal or something that may injure the foot, but if good soles are worn, there is little danger of injury. I have known of a lot of accidents caused by improper dress.

Philadelphia, Penn. W. H. NOSTAN.

Simplex Pressure-Reducing Valve

There appeared a description of a pressure-reducing valve on page 700, of the Nov. 20 issue of *Power*. A simple device and it will doubtless do all that is claimed for it. One thing that arouses my curiosity is as to why the accumulation of fittings at the right of the valve are used.

First there is a flange, then a short nipple, followed by a reducing coupling; next is another short nipple and a peculiar-shaped tee into which one end of the low-pressure pipe line is screwed.

What's the idea? Do the manufacturers deal in pipe fittings or are they in cahoots with a pipefitter gang? Why can't the main steam pipe connect with the flange that is secured to the valve? There is no need for the tee fitting, as the small pipe connecting the diaphragm chamber with the pipe line could be screwed into a tapped hole in the pipe just as well. That would simplify the pipe work, and the small pipe connection could be made at any desired place without fussing with a tee connection. How about it?

Chicago, Ill. M. A. NELSON.

A troubleman sent to investigate the cause of a wasteful engine, found that steam was blowing through the exhaust valves in large quantities. The negro in charge upon questioning replied: "Well, boss, de engin' was left goin', puff, puff, jerky-like"—pointing to the exhaust line. "I knowed no engin' should run like dat, so I took my wrench and fixed her so she'd go whoooosh, whoooosh, stiddy-like."—*H. B. McDermid.*

Inquiries of General Interest

Kilowatts Developed by Water Power—How many kilowatts would be developed by a water power which has a head of 80 ft. and a flow of 100,000,000 gal. per 24 hours?
W. T.

Allowing 8⅓ lb. per gal., the energy developed by the water would be 100,000,000 × 8⅓ × 80 = 66,666,666,666 ft.-lb. per 24 hours, or 66,666,666,666 ÷ (24 × 2,654,200) = 1046.5 kw. Allowing an efficiency of 78 per cent. for the waterwheel and 94 per cent. for the generator, the electrical power would be 1046.5 × 0.78 × 0.94 = 767.3 kilowatts.

Utilizing Low Grade of Coal—Since using a poorer grade of coal we are unable to obtain former normal boiler capacity of our return-tubular boilers. The furnace fires cannot be made to burn briskly. With careful firing the coal seems to simply glow, and the same trouble is experienced when it is attempted to operate two boilers with a stack formerly found to be ample for three boilers. How can the poorer grade of coal be burned to better advantage?
C. K. W.

Probably the tube, breeching and chimney areas are large enough, but the results signify that there is not sufficient force of draft. The poorer grades of coal are usually low in volatile matter and contain earthy matter that prevents through and through kindling without a strong enough draft to induce combustion by impingement of the air supply against the warmed fuel. The remedy would be either to increase the height of the stack, or install a mechanical draft apparatus.

Temperature Resulting from Compression of Air—When free air, or air at a pressure of 14.7 lb. absolute and 60 deg. F., is compressed to 29.4 lb. absolute without loss or gain of heat except the increase of heat due to compression, what will be the temperature after compression?
N. H. T.

The compression would be adiabatic. Where R = the ratio of adiabatic compression or expansion, the temperature varies as $\frac{1}{R}^{0.22}$. When air at 14.7 lb. absolute is compressed to 29.4 lb. absolute, the value of R is $\frac{14.7}{29.4}$, or 0.5; then $\frac{1}{R} = 2$.

$Log\ 2^{0.29} = log\ 2 \times 0.29 = 0.30103 \times 0.29 = 0.0872987 = log\ of\ 1.22.$

If the initial temperature was 60 deg. F. or 60 + 461 = 521 deg. absolute, the temperature after compression would be, 521 × 1.22 = 635.6 deg. absolute = 635.6 — 461, or 174.6 deg. F.

Allowable Pressure for Unstayed Heads—What would be the safe working pressure for the unstayed heads of an air tank made of ⅜-in. steel, 48 in. in diameter and dished to a radius of 48 in., where one head receives pressure on the concave and the other on the convex side, without handholes or manhole in either head?
B. E.

The allowable working pressure for dished or bumped heads with pressure on the convex side is 60 per cent. of that allowable for heads of the same dimensions with the pressure on the concave side. The formula for unstayed dished heads with pressure on the concave side is

$$t = \frac{5.5 \times P \times L}{2 \times TS} + \frac{1}{8}$$

where

T = Thickness of plate, inches;
P = Maximum allowable working pressure, pounds per square inch:
TS = Tensile strength, pounds per square inch;
L = Radius to which the head is dished, inches.

Substituting the given thickness of ⅜ in. and TS of 55,000 lb. and allowing 60 per cent. of the pressure obtained by the formula, in order to find the working pressure for the head subjected to pressure on the convex side and radius of 48 in., the formula becomes

$$\frac{3}{8} = \frac{5.5 \times (0.60 \times P) \times 48}{2 \times 55{,}000} + \frac{1}{8}, \text{ from which}$$

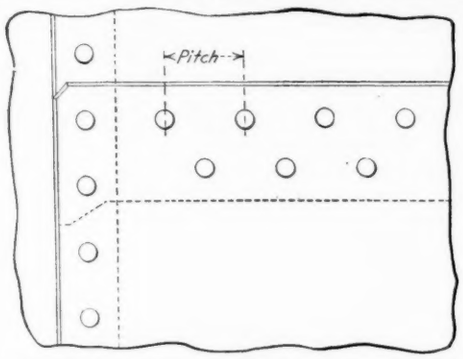
633.6 P = 110,000 or P = 173 lb. per sq.in. working pressure for the weaker head.

Working Pressure for Longitudinal Joint of Air Tank—What would be the safe working pressure for the longitudinal, double-riveted lap joint of an air tank made of ¼-in. steel plate of 55,000 lb. tensile strength with ⅞-in. diameter rivets to fill ¾-in. diameter holes pitched 2 in.?
A. A.

In good practice the factor of safety for air tanks having a longitudinal joint of lap-riveted construction is taken as 5 for new tanks, or tanks not over 10 years old and in good condition of material and workmanship, and therefore the longitudinal joint could be employed for a safe working pressure of

$$P = \frac{55{,}000 \times ¼}{24 \times 5} \times \textit{efficiency of the joint, or } 114.58 \times \textit{per cent. of efficiency.}$$

The cross-sectional area of each rivet after driving would be ¾ × ¾ × 0.7854 = 0.4418 sq.in., and the allowable shearing strength for steel rivets in single shear would be 44,000 lb. per sq.in. of cross-section. Then for a length of the joint equal to a unit of pitch as shown in the sketch,



(A) Strength of solid plate would be = 2 × ¼ × 55,000 = 27,500 lb.
(B) Strength of plate between rivet holes = (2 — ¾) × ¼ × 55,000 = 17,187.5 lb.
(C) Shearing strength of two rivets in single shear = 2 × 44,000 × 0.4418 = 38,878 lb.
(D) Crushing strength of plate in front of two rivets = 2 × 0.75 × ¼ × 95,000 = 35,625 lb.

As the least strength is derived from consideration (B), namely, 17,187.5 lb., and the percentage of efficiency of the longitudinal joint is $\frac{(B)}{(A)} = \frac{17{,}187.5}{27{,}500} = 62½$ per cent. of the strength of the solid plate, the safe working pressure would be 114.58 × 0.625 = 71.61, or practically 72 lb. per square inch.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Stokers vs. Hand-Firing for 600-Hp. Plant

Report of a debate on stokers versus hand-firing for a 600-hp. plant by David Larkin, chief engineer, Fifth Avenue Building, and John Elder, chief engineer, Adams Express Building for the stoker; W. D. Lewis, chief engineer, Bradstreet Building and Herman Fiebig, chief engineer, Eberhard Faber Pencil Co., for hand-firing.

MR. ELDER and Mr. Larkin are both of Phoenix Association, No. 24, N. A. S. E.; Mr. Lewis is from No. 8 and Mr. Fiebig from No. 25, Brooklyn, N. A. S. E. Frederick Felderman, No. 44, New York, N. A. S. E., presided. Each speaker was limited to fifteen minutes, and this time proved to be inadequate. The debate took place in Phoenix Association, N. A. S. E., East 15th St., New York City.

Among the claims made for the stoker by Mr. Elder, who opened the debate, were the following: Even and continuous firing; more uniform supply of air; continuous and practically automatic cleaning of the fire, eliminating hard labor in the boiler room; smokelessness and ability to successfully burn low-grade coal.

Speaking of the flexibility of the stoker as regards steaming capacity, Mr. Elder quoted results of flexibility tests at the plant of the Iowa Railway and Light Co., Cedar Rapids, Iowa. The boilers are the Edge Moor, 627-hp., fired by 7-retort Taylor stoker. After operating six hours at low rating, the boiler was made to increase its output from 320 hp. to 1500 in three minutes. With the same boiler and stoker the boiler output was jumped from zero to 1920 hp. in five minutes. On another test, with Colorado lignite fuel, the stoker was started with the fire at a "dead" bank, and in 7½ min. the boiler was producing 1300 hp. The fuel had the following composition: Moisture, 18.62 per cent.; volatile, 40.70 per cent.; fixed carbon, 34.17 per cent.; ash, 6.51 per cent.; and B.t.u. as fired, 9768. This ability of the stoker to quickly increase the boiler capacity from zero at dead bank to considerably above rating is most desirable in factory and mill plants that shut down over night, Mr. Elder claimed.

A 600-hp. plant likely would have three 200-hp. boilers. Mr. Elder then produced test results from a stoker-fired boiler of 200 hp. The coal had the following value: Moisture, 14.40 per cent.; volatile, 30.75 per cent.; fixed carbon, 41 per cent.; ash, 13.85 per cent.; and the B.t.u. value as fired was 10,556. The mean percentage of builders' rating for the test was 97.57 per cent., the actual evaporation per pound of coal as fired was 8.253 lb., and the combined boiler efficiency was 81.16 per cent.

Saving Effected in Small Plants

To show the saving in labor and coal effected by the stoker even in small plants, Mr. Elder cited the case of a plant having four return-tubular boilers of 150 hp. each. These were hand-fired, New River coal, a high-grade, high-priced fuel; two firemen and one coal-passer were employed. The average evaporation was 8.3 lb. of water per hour per pound of coal as fired. Underfeed stokers costing $7.31 per horsepower were installed under these boilers, after which the boilers were run with one fireman and the fuel changed to a mixture of No. 3 buckwheat 33 per cent. and New River 67 per cent., giving an average evaporation of 8.42 lb. of water per hour per pound of coal as fired. Mr. Elder contended that a mixture of hard and soft coal could be satisfactorily burned on nearly all, if not all, stokers.

Mr. Lewis now took up the case of hand-firing. He claimed that the city-building plant, located in a basement, as it is usually, is unsuited to stokers on account of the lack of overhead coal bunkers to gravitate the coal to the stoker hoppers. He asserted that it needed no argument to convince an engineer that in the average 600-hp. plant no saving in labor could be made by changing from hand- to stoker-firing. Mr. Lewis was sure that the investment, together with the overhead and no reduction in labor, would so increase the charges against the stoker that the increased efficiency of operation would not pay.

Ten Advantages of the Stoker

Mr. Larkin now took the floor and enumerated the following ten advantages of the stoker:

1. Greater steaming capacity for the same given grate area. An instance is the Fifty-ninth Street Power House of the Interborough Rapid Transit Co., New York, where the kilowatt output was increased 100 per cent. without any increase in installed boiler capacity, due entirely to the high combustion rates possible with the stoker.

2. Greater average daily efficiency. It is not necessary to spend time cleaning fires as they are cleaned automatically. The stoker will adjust itself to various load conditions.

3. Ability to more efficiently use the lower grades of fuel. It is possible to use any low grade of fuel hand-fired, but it cannot be done as economically as with stokers.

4. Reduction in labor per unit of output. In a boiler plant of 600 hp., whether it consists of one unit of 600 hp., two units of 300 hp. each, or three units of 200 hp., the labor costs are cut in two, and in the case of a larger plant the labor cost is reduced to a far greater degree. He had installed four 750-hp. boilers in one room with stokers and handled it with one man very successfully, whereas this boiler room could not have been handled by less than four firemen and four ash handlers or coal passers per watch, costing, per day of 24 hours, $36 for firemen and $30 for coal passers, making a total of $66 per day, or $24,090 per year. With the stoker, it cost only $9 per day, or $3280 per year, and in addition it was possible to get double the rating with the stoker. These stokers were installed at a cost of $15,000, and with 6 per cent. interest on the investment, it cost, at the end of one year, $15,900; the difference in labor cost is $21,810, making the saving on labor alone in the first year $5910. Any installation that will pay for itself in five years is considered a good investment.

5. Reduces stresses on boilers as stokers avoid inrush of cold air to the heating surfaces.

6. Greater flexibility in control of fires. Regardless of what change takes place in load, there is no loss of steam as the same even steam pressure is maintained, assuring better efficiency of the engines.

7. Greater freedom from smoke.

8. Greater assurance of uninterrupted service. Service is interrupted many times by something going wrong with a boiler, and when running up to the capacity of the plant it is not possible to take care of the increased pull on the other boilers as easily when hand-fired as when stoker-fired.

9. Cleanliness in boiler room—very important in many branches of industry.

10. Far greater freedom from labor troubles in the boiler room, and further, in the event of such trouble, it is easier to maintain continuous service with the stoker than with hand-fired furnaces.

Assuming 10 per cent. better average daily efficiency with the stoker over hand-firing, Mr. Larkin produced the following figures to show the saving effected by the stoker:

Assuming that the stoker burns 10 per cent. less fuel for the same average boiler output, which is a very fair assumption, and taking 3.5 lb. of coal per boiler horsepower, a 600-hp. stoker-fired boiler would use 2100 lb. of coal per hour at rated capacity, or 50,400 lb. per day of 24 hours. At $4.50 per ton, the yearly coal cost for a 300-day year is $34,020. Ten per cent. greater coal consumption for the hand-fired plant would increase the yearly coal consumption $7560 \times 0.10 = 756$ tons, which, at $4.50 per ton, equals $3402 per year as the greater fuel cost with hand-firing over stoker-firing.

Mr. Fiebig next defended hand-firing. He took two installations, one stoker- and one hand-fired, and assumed

the efficiency of the hand-fired boilers to be 66 per cent. and that of the stoker-fired 70 per cent. He exhibited calculations on large sheets, about 4 x 4 ft., to show that for a 10-hour day the stoker, allowing for the steam consumed in driving it, 2 per cent., would save 1000 lb. of coal for the same output. At present coal prices this gives a coal saving of $2.50 per day.

Mr. Fiebig then produced the following figures to show that the total daily costs favored the hand-fired installation.

HAND-FIRED INSTALLATION COSTS

Brickwork and settings	$5,200.00
Dumping grates	1,020.00
Total investment	$6,220.00
Interest on investment at 6 per cent	$373.20
Maintenance, brickwork and grates (actual)	169.00
	$542.20
Fixed charges per day	$1.81
Labor:	
Two firemen at $20 per week	$2,080.00
One fireman at $16 per week	832.00
One coal-passer at $15 per week	780.00
	$3,692.00
Labor cost per day	$12.32
Total daily cost	$14.13

STOKER-FIRED INSTALLATION COSTS

(No coal bunker or coal or ash conveyor)

Brickwork	$8,400.00
Stokers and draft fan at $9 per boiler hp	5,400.00
Total investment	$13,800.00
Interest on investment at 6 per cent	$828.00
Maintenance at 4 per cent	552.00
Total fixed charges	$1,380.00
Fixed charges per day	$4.60
Labor:	
Two firemen at $20 per week	$2,080.00
One fireman at $16 per week	832.00
One coal-passer at $15 per week	780.00
	$3,692.00
Labor cost per day	$12.32
Total daily cost (stoker)	16.92
Total daily cost (hand-fired)	14.13
Difference in favor of hand-firing	$2.79

STOKER-FIRED INSTALLATION COSTS

(Coal bunker and vacuum ash conveyor)

Investment:	
Brickwork	$8,400.00
Stokers and draft fan at $9 per hp	5,400.00
300-ton storage bin at $20 per ton	6,000.00
Ash conveyor	4,000.00
Total investment	$23,800.00
Interest on investment at 6 per cent	$1,430.00
Maintenance stoker and brickwork at 4 per cent	552.00
Depreciation of storage bin at 4 per cent	300.00
Depreciation and maintenance, ash conveyor, 10 per cent	400.00
Total fixed charges	$2,682.00
Total daily fixed charges	$8.95
Labor:	
Two firemen at $20 per week	$2,080.00
One fireman at $16 per week	832.00
	$2,912.00
Total daily labor cost	$9.70
Total daily costs (stoker)	18.65
Total daily costs (hand-fired)	14.13
Difference in favor of hand-firing	$4.52

Mr. Fiebig then pointed out by calculations that bituminous coal is at this time difficult to get in New York City and costs considerably more than anthracite, thus causing stoker installations to suffer more than hand-fired anthracite plants during this coal shortage at the point of consumption.

Mr. Elder was allowed five minutes for rebuttal, but did not respond.

The audience voted overwhelmingly in favor of Mr. Fiebig and Mr. Lewis, who defended the hand-fired boiler. The subject was opened to general discussion. William Reynolds, chairman, National Board of Trustees of the Association, praised the educational value of the meeting. Charles H. Bromley, associate editor of *Power*, responded to Chairman Felderman's invitation for remarks by saying that he feared many might go away with too high opinions of hand-firing as against stoker-firing. "Hand-firing must go," said Mr. Bromley. "It is a national waste of energy, thermal and muscular." He thought it was stretching a point for Messrs. Lewis and Fiebig to condemn the stoker for the basement plant because "an overhead coal bunker could not be used." Coal could be taken from the under-the-sidewalk bunker and transferred to the stoker hoppers with an electric coal larry, he said. Mr. Bromley highly praised the hand-fired furnace designed by Henry Misostow, of the Chicago Smoke Inspection Department, and that used by the City of Cincinnati, but said that for any size plant stokers in proper boiler settings were to be recommended, as there were stokers to meet the needs of all plants however large or small. Anthracite will comparatively soon cease to be a steam coal even in the East, he claimed, and stokers are unquestionably better adapted to smokeless and economical combustion of soft coal.

Debates on many other subjects will be held in various associations in Manhattan, Bronx and Queens during the winter. The next was on Nov. 24 at No. 25 N. A. S. E., Terrace Garden, Lexington Ave. and 58th St., New York City; the subject was "Hydraulic vs. Electric Traction Elevators."

Program of A. S. M. E. Meeting

The thirty-eighth annual meeting of the American Society of Mechanical Engineers will be held at the society's headquarters in New York, Dec. 4-7. A very interesting professional and attractive social program has been arranged, as follows:

Tuesday, Dec. 4—At 12 m., opening of Registration Bureau in Engineering Societies Building; 12:30 p.m., conference luncheon, Council and Sections delegates; 2 p.m., Council meeting; 2 p.m., meeting of Gage Committee; 2 p.m., Sections conference; 8:30 p.m., report of tellers of election and introduction of the president-elect; conferring of honorary membership upon Maj. Gen. George W. Goethals, followed by an address by Hon. William H. Taft; reception by the president and the president-elect.

Wednesday Morning, Dec. 5—Business Meeting: Amendments to the constitution and bylaws; reports of standing committees; address on the "Activities of the Society for 1917," by President Hollis; presentation to the society of a bust of Admiral B. F. Isherwood; reports by subcommittees of the Research Committee. The consent of the meeting will be asked to adjourn the business meeting to Thursday morning in order to allow time for the addresses of the Keynote Session on "The Service of the Engineer to the Public in Times of Crises." At this session Dr. Ira N. Hollis, president of the society, will deliver an address on "Universal Public Service in Peace and War." Other addresses will be given by distinguished men of national reputation on the following subjects relating to problems incident to the war: "Coöperation of Engineers," "The Agricultural Problem," "The Fuel Problem," "Engineering Research," "Special Education in War Time," "Building a Merchant Marine," "Rail Transportation," "Motor Transportation," "The Aircraft Problem," "Cantonments." This will be an all-day session.

Buffet luncheon will be served at 12:30 p.m.

Wednesday Afternoon—Simultaneous sessions of Power-Plant, General and Industrial-Safety Sessions will be held. Power-Plant Session: "Preventable Waste of Coal in the United States," David Moffat Myers; "A Commercial Analysis of the Small Turbine Situation," W. J. A. London; "Bagasse as a Source of Fuel," E. C. Freeland; "The Cooling of Water for Power-Plant Purposes," C. C. Thomas; "The Steam Motor in the Automotive Field," E. T. Adams. General Session. "The Transfer of Heat Between a Flowing Gas and a Containing Flue," Lawford H. Fry; "A Study of Surface Resistance with Glass as the Transmission Medium," H. R. Hammond and C. W. Holmberg; "Apparatus for Cooling, Drying and Purifying Air," W. J. Baldwin; "Recent Developments in Balancing Apparatus," N. W. Akimoff; "Plotting Blower-Test Curves," A. H. Anderson (by title only); "Cross-Current Predeterminations from Crank-Effort Diagrams," Louis Illmer (by title only). At the Industrial-Safety Session two codes will be presented for discussion by

the subcommittee on Protection of Industrial Workers, on Safety Standards for Elevators and Woodworking Machinery. At 3:30 p.m.: Meeting of Committees on Increase of Membership; ladies' reception and tea. 4:30 p.m., Student Branch Conference.

Wednesday Evening Smoker—Get-together meeting for members. John R. Freeman, past president, will give an illustrated talk upon his trip to the Orient taken last winter with Dr. John A. Brashear and Ambrose Swasey, past presidents. Music by Glee Club. Refreshments.

Thursday Morning, Dec. 6—At 9:45, business meeting continued, followed by general sessions. A Local-Sections Session will be held under the direction of the Sections Committee, for a discussion of the work of the sections and of society affairs, by representatives of the 24 sections of the society. General Session: "An Account of the Engineering Work of E. D. Leavitt," F. W. Dean; "An Exact Volume Regulator for Blast-Furnace Engines," L. C. Loewenstein; "Expenses and Costs," H. L. Gantt. The following papers contributed by local sessions will be presented by title: "By-product Coke and Coking Operations," C. J. Ramsburg and F. W. Sperr, Jr.; "The Submarine," C. H. Bedell; "Combined Stresses," A. L. Jenkins; "The Trumble Refining Process." N. W. Thompson. At 10 a.m., joint meeting of A. S. M. E. and S. A. E. Committees on Steel Roller Chains.

Luncheon will be served at 12:30, at which there will be an address on "The Relation of Industrial Management to Engineering," by Prof. Dexter S. Kimball.

Thursday Afternoon—Simultaneous sessions of Machine-Shop and Textile Sessions. Machine-Shop Session, under the auspices of the subcommittee on Machine-Shop Practice: Topical discussion on the subject of inspection, with the following introductory discussions: "The Logic of Inspection," A. L. DeLeeuw; "The Relation of Inspection to Product," F. A. Waldron; "General Principles of Government Inspection and Relations Between Inspectors and Manufacturers," Col B. W. Dunn. Textile Session, under the auspices of the subcommittee on Textiles: "Labor-Turnover Records and the Labor Problem," Richard B. Gregg; "Accident Prevention in the Textile Industry," David S. Beyer; "The Moisture Content of Textiles and Some of Its Effects," William D. Hartshorne.

Thursday Evening—Lecture, "The Beautiful in Commonplace Things," Dr. John A. Brashear. Following the lecture there will be a reunion and dance, with refreshments, on the fifth floor of the Engineering Societies Building.

Friday Morning, Dec. 7—Simultaneous sessions. Management Session: Topical discussion on the "Employment of Women in the Skilled Industries," with particular reference to war conditions. To be introduced by John W. Upp, General Electric Co., and C. B. Lord, Wagner Electric Manufacturing Co.; "The Engineer, the Cripple and the New Education," by Maj. Frank B. Gilbreth. Power-Test Hearing: A public hearing by the Power Test Committee, preliminary to a proposed revision of the Power Test Code of the society, comprising rules for conducting tests on prime movers of different types, and auxiliary apparatus.

Friday Afternoon—Council meeting.

Friday Evening—College reunions.

State Engineering Under One Head

A law creating a department of engineering for the State of Wisconsin was passed Aug. 7, 1915, and John G. D. Mack was appointed state chief engineer. The work is divided into five main divisions: (1) Railroad, (2) Highways, (3) Architecture, (4) Power Plant, and (5) Sanitary. The report of the power-plant division by the state power-plant engineer, John C. White, for the first three months is, in part, as follows:

The work of the division consists of the supervision of operation of the various state plants, including the purchase of fuel and supplies, and the keeping of records; the preparation of plans and specifications for improvements in them and superintending construction work; investigating and advising on, and sometimes taking charge of, repair work at the state institutions; examining and checking up plans and specifications from architects and engineers, and tabulations and analyses of bids and recommendations for acceptance. Also, by direction of the board of health, where the public health or safety is concerned, this division is sometimes employed to investigate and report on other than state work, such as the heating and ventilating apparatus of public-school buildings in the smaller towns. It is the intention to conduct the work of the department along the following lines:

Operation—Personnel: There is probably as good average material in the operating crews as can be obtained for the salaries paid. Improvement will therefore be best accomplished by providing means for educating and instructing the present staff and inspiring them to closer attention and greater effort, gradually supplanting those who cannot or will not respond and encouraging those who coöperate and prove their worth, by increased salaries, shorter hours in many cases and greater responsibilities and promotions where possible. To this end we have enlisted the aid of the civil-service commission and through them the extension division of the university and have prepared courses well adapted to the needs of the men and the service. By the coöperation of the various governing boards these courses have been placed within the reach of all at a minimum cost. We have held one three-day session of a school for chief engineers at Madison, which was well attended and generally successful, and we hope to make it an annual affair. The division will endeavor to operate the equipment now installed to the best advantage by examining and improving methods and advising with the men as to proper operation and maintenance. This involves supervision of units in service and capacities for the different requirements, methods of firing, stopping leaks, keeping boilers and furnaces clean and in good condition, the economical use of lubricants, packings, etc., systematic methods of inspection, keeping accurate records and assisting in perfecting the organization, and defining the duties and responsibilities of all employees.

Preventable Waste of Coal in the United States*

BY DAVID MOFFAT MYERS

Six hundred million tons of coal were mined in the United States in 1916. If we assume only one-half of this to have been used for industrial boiler plants, then a quarter of the coal used under boilers amounts to 75,000,000 tons per year.

This proportion can readily be saved. A 14-day test of the boilers of a steel mill showed an efficiency of 55 per cent. The load factor was unusually favorable to high efficiency and could readily be raised to 70 per cent. or over. The mill was wasting 40,000 tons of coal per year. In another hand-fired plant the evaporation was raised from 6 to 9 lb. in a few days of instruction, and continuously kept close to this higher mark with the help of coal and water measurements that were inaugurated. The saving was due exclusively to instruction and consequent better operation.

Under present conditions a plant that carelessly operates at an efficiency of 40 to 50 per cent. receives from the Government the same consideration in the delivery of coal as one the efficiency of which is 70 to 75 per cent. It is obviously unfair, as well as wasteful. The Government hands over, say 200,000 tons of coal a year to a plant owner, but asks for no account as regards its consumption, nor any questions as to the amount of steam it is made to produce.

The author hopes that his paper will open a discussion which may ultimately lead to the formulation of definite recommendations of means for the reduction of the present great preventable waste of fuel in our industries, that the society will forward the recommendations to the proper governmental authorities as an official communication and offer to the Government the services of the society for the organization, furthering and, as far as possible, the execution of the plans that may as a consequence be adopted.

*Abstract of a paper to be presented at the December meeting of the American Society of Mechanical Engineers.

One plan would be to involve the use of authority to compel coal consumers to execute such measures of economy as the proper authorities might prescribe, limits to be set as to the expense to the user. Another plan would be largely an educational one, in which patriotism and efficiency would furnish the motive.

Instruction would be furnished in a simple form that could be understood by plant owners and operators; the vital importance of daily accurate records of coal and water must be taught and information given regarding practical appliances for automatic measurements of both. This work would be greatly aided by a staff of experts ready to visit plants when so requested, and make investigations and recommendations, also to deliver talks, which should be planned so as to reach directly not only managers and owners of the industries, but also the chief engineers and firemen of the boiler plants.

Bagasse as a Source of Fuel*

By E. C. Freeland
Louisiana State University, Baton Rouge, La.

Bagasse chemically consists mainly of a tough fiber, sugar or sucrose, glucose, and other reducing sugars and water. The fiber content ranges from 30 to 50 per cent., the sucrose from an almost negligible quantity to as high as 10 per cent., and the water from 40 to 65 per cent.; the other constituents occur in such small amounts that they are here disregarded. The composition of bagasse varies greatly according to the method and effectiveness of milling the cane, good milling resulting in a bagasse very suitable for burning. In Louisiana the fiber content averages about 40 per cent. and the moisture about 53 per cent., the remaining 7 per cent. being mainly sucrose. Several methods are in use for calculating the fuel value of bagasse. In this country Prof. E. W. Kerr's formula is in general use. The fuel value of one pound of bagasse is calculated by him as follows:

The heat value of one pound of dry bagasse, by experiment, is 8300 B.t.u. Assume that the moisture content of a bagasse is 48 per cent. and that this bagasse is burned in a furnace the stack temperature of which is 500 deg. F.; 100 — 48 = 52 per cent. dry matter in the bagasse; 52 per cent. × 8300 = 4316 B.t.u. in the dry bagasse. Assume that the temperature of the bagasse is 80 deg. F., then the water in the bagasse will have to be raised from 80 deg. to its boiling point, 212 deg., and then vaporized before the bagasse can be completely burned. The calculations for the heat necessary to vaporize this water are as follows:

212 deg. F. — 80 deg. = 132 deg. F.; 500 deg. F. — 212 deg. = 288 deg. F.

The heat necessary to raise the water in one pound of bagasse to the boiling point equals 0.48 × 1 × 132 = 63.4 B.t.u.

Heat necessary to vaporize the water in one pound of bagasse from 212 deg. = 0.48 × 1 × 970 = 465.6 B.t.u.

Heat necessary to superheat the vapor from 212 to 500 deg. = 0.48 × 1 × 288 × 0.5 = 69.1 B.t.u., where 0.5 is taken as the specific heat of superheated steam.

Heat lost in the water equals 63.4 + 465.6 + 69.1 = 598.1 B.t.u.

The net heating value of one pound of bagasse equals 4316 — 598.1 = 3717.9 B.t.u.

The average Louisiana bagasse has a calorific value of about 8300 B.t.u. per pound of dry bagasse and from 3620 B.t.u. gross (with bagasse containing 56.7 per cent. moisture) to 4800 B.t.u. gross (containing 42.8 per cent. moisture). The net heating values are respectively 2200 and 3350 B.t.u.

One pound of bagasse will evaporate from 2 to 3½ lb. of water from and at 212 deg. F. Assuming coal and fuel oil to have, respectively, a heating value of 14,000 and 19,000 B.t.u. per lb., then from 4 to 6 lb. of bagasse is equivalent to one pound of coal and from 43 to 65 lb. equivalent to one gallon (about 7.6 lb.) of oil.

*Abstract of an article in the November "Journal" of the American Society of Mechanical Engineers.

Professor Kerr, of the Louisiana State University, found that at a Louisiana sugar house the bagasse from one ton of cane generated from 1.16 to 1.44 boiler horsepower. Thus, the bagasse from a 1000-ton house per 24 hours will generate a total of 1160 to 1440 b.hp.-hr. during that period. It would require about 60 tons of coal per day to do the same work, assuming that the coal equivalent to the bagasse from one ton of cane is 120 lb. Professor Kerr further stated that in Louisiana 16 per cent. of the total heat generated by the combustion of one pound of bagasse is required to evaporate the moisture present in the bagasse. About 14½ per cent. of the moisture in Louisiana bagasse was removed by drying it, and the dry bagasse had a heating value 55 per cent. greater than the wet bagasse. This means that a saving of over 2½ gal. of oil will be effected per ton of cane ground. In a factory grinding 60,000 tons of cane per season, this means a saving of about 154,000 gal. of oil, or 3670 bbl., which, at $1.25 per barrel, means a saving of $4587.50 per season for fuel oil.

The grate surface should be small in furnaces used for burning bagasse, as the rate of combustion is high, sometimes running up to 300 lb. per hour per square foot of grate surface. This corresponds to about 20 boiler horsepower per square foot of grate surface. Some of the recently installed 500-hp. boilers in the tropics have only 25 sq.ft. of grate surface. Small grates require less manipulation and care to prevent excessive air losses than in the case of large grates, there being less danger of portions of the grate being uncovered. The amount of grate surface per boiler horsepower varies with the amount of moisture in the bagasse—the less moisture there is the smaller the grate surface.

Of late, especially in Cuba and Hawaii in large factories, stokers are being put in to use the dry bagasse. These stokers are mainly of the step-grate type with front feed and others with double (side?) feed. The bagasse is spread at the top or upper back part of the stoker, in the same manner as coal. These stoker furnaces have proved to be an effective means of drying the bagasse, as well as regulating the combustion or burning of this fuel.

It may be said that, although many improvements have recently been made in the methods of burning bagasse, there are yet many further improvements to be made. Methods of regulating the air supply, improvements in furnaces and driers, and utilization of the heat in the waste flue gases are some of the problems being worked upon by the sugar-house engineers.

Interpretations by the Boiler Code Committee

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information as to the application of the Code is requested to communicate with the secretary of the committee, C. W. Obert, 29 West 39th St., New York City.

Following are the interpretations of the committee in Cases Nos. 174-176, inclusive, as formulated at the meeting of Sept. 20 and approved by the Council on Oct. 12, 1917:

Case No. 174—Inquiry: What type of stays does Par. 200 of the Boiler Code refer to in its requirements for the drilling of telltale holes in their ends? The rules of the Interstate Commerce Commission establish the distinction that all stays shorter than 8 in. in length shall be termed stay-bolts.

Reply: It has been proposed to revise Par. 200 to read as follows:

200. Stay-Bolts. The ends of screwed stay-bolts shall be riveted over or upset by equivalent process. Stay-bolts must be hollow or the outside ends of solid stay-bolts 8 in. and less in length shall be drilled with a hole at least $\frac{5}{16}$ in. diameter to a depth extending at least ½ in. beyond the inside of the plates, except on boilers having a grate area not exceeding 15 sq.ft., or the equivalent in gas- or oil-fired boilers, where the drilling of the stay-bolts is optional. Solid stay-bolts over 8 in. long and flexible stay-bolts of either the jointed or ball-and-socket type need not be drilled.

Case No. 175—Inquiry: Is it necessary under the rules

of the A. S. M. E. Boiler Code that the outside firebox plate of locomotive-type boilers be of the same thickness as the barrel sheets when stayed to the inner firebox sheet? It is customary in locomotive-boiler practice to make the outside firebox plate of less thickness than the barrel plate because of this form of staying.

Reply: The committee now has this matter under consideration and will render a formal reply as soon as the investigations now under way have been completed.

Case No. 176—Inquiry: What factor of safety shall be used under the rules of the Boiler Code, (a) when the longitudinal joint of a dome less than 24 in. in diameter is lap-riveted, and (b) when such dome is attached to the shell of the boiler by a flanged ring construction in accordance with Par. 261?

Reply: When the longitudinal joint of a dome less than 24 in. in diameter is lap-riveted, the longitudinal barrel of the dome must be designed on the basis of a factor of safety of not less than 8. When such a dome is attached to the shell of the boiler by a flanged ring construction, in accordance with Par. 261, the flanged construction shall have a factor of safety of not less than 5, but this does not involve any change in the factor of safety of not less than 8 in the dome barrel.

The New War-Savings Certificates and Thrift Stamps

Beginning Dec. 3, 1917, the Government will offer for sale an issue of War-Savings Certificate Stamps, Series of 1918, which will have a maturity value of $5 each on Jan. 1, 1923. These stamps may be purchased at post offices and at numerous banks and other agencies to be appointed by the Secretary of the Treasury. They are designed to give every person in the United States an opportunity to aid the Government in financing the war, and at the same time they represent the safest and best gilt-edge investment opportunity ever offered. They will be sold in December, 1917, and January, 1918, for $4.12. On the first of every month thereafter, the price will advance one cent; that is, they will cost $4.13 during February, $4.14 during March and so on. On Jan. 1, 1923, they will be redeemed at $5 each, thus paying 4 per cent. interest, compounded quarterly.

When a person buys his first war-savings stamp, he is given a certificate which bears the obligation of the United States and upon which there is space to attach twenty $5 stamps. These certificates may be registered without cost at any post office of the first, second or third class; the owner's name and address will be written upon each certificate, and if lost no one else can cash it except by committing forgery. In the unregistered form it can be cashed by anyone at any time at any post office.

The owner of a war-savings certificate may at any time prior to Jan. 1, 1923, go to any money-order post office and get back the amount he has paid plus one cent a month for each stamp he has bought.

The amount of war-savings certificates that may be held by one person is limited to $1000; the amount sold to any one person at one time shall not exceed $100.

To help the small saver desiring to accumulate the cost of a war-savings stamp, the Government will issue a 25-cent thrift stamp and provide a thrift card having spaces for 16 of these stamps. These thrift stamps do not bear interest, but when a thrift card has 16 such stamps attached, representing $4, it may be exchanged by the payment of a few additional cents for one of the war-savings-certificate stamps.

A war-savings-certificate stamp is virtually a $5 United States Government bond, drawing compound interest at 4 per cent. They are exempt from taxation. They are the only Government securities whose value is established not by market conditions, but by law. Best of all, they are within the reach of almost everybody—man, woman or child—in the country.

Post offices of the United States have been formally made, under the law, a huge selling organization for the war-savings-stamps campaign, and every postal employee has been especially instructed to take an active part in the sale.

Service in American Ordnance Base Depot in France

The American Ordnance Base Depot in France, together with the mobile repair shops accompanying the troops, is charged with the repair and maintenance of the ordnance equipment of the army in the field. It is estimated that the permanent shops alone will in the aggregate be nearly three times as large as the combined manufacturing arsenals in times of peace. The complete project calls for from 15,000 to 20,000 men, requiring 2½ million square feet of floor space. The work requires the relining of guns, repair of gun carriages and artillery vehicles, repair of motor trucks, tractors and tanks, repair of machine guns, and the overhauling and repair of enormous quantities of small arms, horse and personal equipment. Provision is also being made for reloading more ammunition that is now being made in the United States.

Equipment will last but a few months. This is a war of a Mechanical Age. The soldier at the front must be backed up by thousands of co-workers. It is estimated that for each soldier on the line, there are ten men behind him directly or indirectly producing what he requires. The Ordnance Department in the field is in the front rank of these men behind the line, making it possible for the soldier in the trench to "do his bit." It offers an opportunity for a man of almost any trade or profession in civil life to be of real help to his country and still follow his trade, utilizing to the fullest the experience and skill he has gained in the years of peace.

This department also requires the service of draftsmen, electrical engineers, electricians, dynamo tenders, both stationary and locomotive engineers and firemen, boiler inspectors, autogenous welders, etc. Pay ranges from $30 to $61.20 per month, depending upon demonstrated ability and place of service. Enlistment is for duration of the war only. In addition to the regular pay, free quarters, rations, clothing, bedding, medical and dental attention are provided by the Government. Application blanks can be secured at the nearest recruiting office or by writing to the War Department, Office of the Chief of Ordnance, Enlisted Personnel Division, Washington, D. C. Capt. A. M. Stuart, U. S. A., is in charge of the New York ordnance service recruiting office in City Hall Park. Applicants must be between 18 and 40 years, citizens or declarants; must be able to speak, read and write the English language and should have no absolute dependents.

According to the *Scientific American*, a conference has been held by representatives of the United States Bureau of Standards with the engineers of the manufacturers of incandescent lamps for the purpose of revising the general Government specifications for gas-filled lamps. The Government now uses nearly 2,000,000 lamps per year, and purchases are based on these specifications. For the first time it is planned to include specifications for the new gas-filled incandescents.

Notice to Readers of "Power"

The offices and equipment of both the constituent units in the consolidated McGraw-Hill Publishing Co. are now under one roof. In the confusion incident to the removal of what was formerly the McGraw Publishing Co.'s plant from West 39th St. to the Hill Building at 10th Ave. and 36th St., there may be some slight delay in your receiving your copies of *Power* for this and last week. For this we ask your indulgence, with the assurance that after readjustments have been made, the combined facilities of the two big plants will leave nothing to be desired in the way of prompt and efficient service.

New Publications

CENSUS OF MANUFACTURERS

Census of Manufacturers for 1914, issued by the Department of Commerce, Bureau of the Census, presents statistics relating to the manufacture of engines and machinery in the United States for 1914. A data table shows the number of establishments engaged in the production of each of the specified classes of engines and machinery and the value of the production and export of each class. Another table presents figures for each class of engines, the number, total horsepower and their value. Still another table classifies the classes of engines and their value by states.

EFFECTS OF STORAGE UPON THE PROPERTIES OF COAL

Bulletin No. 97 of the Engineering Experiment Station of the University of Illinois, by S. W. Parr, a 40-page bulletin, is a continuation of studies the results of which have been published in Bulletins Nos. 32 and 38 (1909) and No. 46 (1910) under the titles, "The Occluded Gases in Coal," "The Weathering of Coal" and "The Spontaneous Combustion of Coal." The data on storage were obtained during a period of six years, after which the coal was turned over to the power plant for steam generation and boiler tests were made to establish the character of the various samples. These data, together with other facts bearing upon the general subject of coal storage, have thus been accumulated and brought together, forming a record especially noteworthy on account of the experience and skill of the experimenters in the matter of sampling and in the use of analytical and calorimetric methods. Copies of the bulletin may be obtained for 20c. each from the Engineering Experiment Station, Urbana, Illinois.

EVERYMAN'S CHEMISTRY. By Ellwood Hendrick. Harper & Brothers, New York and London, publishers. Size, 5 x 8 in.; 374 pages; cloth. Price, $2 net.

This is the second book of a modern science series planned by Harper & Brothers, intended to present the latest and most authoritative pictures of modern advance in scientific and sociological fields. The intensified interest in matters chemical caused by the great war makes this book particularly timely. It is a real "chemistry book," giving in popular language a view of modern progress in that field, and is designed for those who declare they do not understand anything about chemistry. It tells how chemists think and how their work enters into life and industry on every hand and gives the reader a true chemical view of things. Quoting from the author's preface: "If I have not made it interesting, I shall be to blame, for I assure you the subject is full of interest and delight." The object has probably been attained, as valuable technical information has been presented in an interesting, readable form.

THE DESIGN OF MACHINE ELEMENTS. By W. G. Dunkley, B. Sc. Published by D. Van Nostrand Co., 25 Park Place, New York City. Two volumes, with 4½ x 7¼-in. pages. Vol. I, 123 illustrations and 16 tables. Vol. II, 122 illustrations and 15 tables. Price, $3 for the two volumes.

These little books are a part of the Broadway Series of Engineering Handbooks. In presenting the main principles on which the design of machine elements is based, the author has used as illustrations many practical examples that have come within his experience as a machine-tool designer. There is little that is new or presented in a new way, as the material used is very similar to that in various other books on design of machine elements. Considerable of the matter has been published in technical magazines or other publications. The general arrangement, however, is very good, and the matter is put in convenient form for ready reference which, after all, was probably the main object in view.

The contents of Vol. I are: Conditions for Equilibrium Between Forces Acting on a Body; Stress, Strain, Twisting and Bending Moment; Shafts and Studs; Bearings, Pedestals, Hangers, Wall Brackets, and Swivel Bearings; Ball- and Roller-Bearings; Keys and Couplings; Springs.

The contents of Vol. II are: Screw Threads, Bolts and Screws; Belts and Pulleys; Driving Clutches; Gearing—Spur Gears with Involute Teeth, Helical Gears, Worm Gearing, Spiral Gears, Bevel Gears, Elliptic Gears; Driving Chains, Lifting Chains, Wire Ropes.

HANDBOOK OF CHEMISTRY AND PHYSICS. The Chemical Rubber Co., Cleveland, Ohio. 1917; fifth edition; cloth; 4 x 6½ in.; 410 pages. Price, $2.

The avowed aim in preparing this book is to present in one compact, easily portable volume a comparatively comprehensive reference book for use in the laboratory or classroom, but not as a competitor of the many large and complete reference books already published. The present edition (the fifth) has been thoroughly revised and substantially enlarged. The table of contents is divided into some fifteen heads as follows: General chemical tables, properties of matter, heat, hygrometric and barometric tables, sound, electricity and magnetism, light, miscellaneous tables, definitions and formulas, measures and units, wire tables, mathematical tables, list of apparatus and material for experiments in chemistry, bibliography and problems. All of the foregoing, it must be understood, is prepared especially for the laboratory worker and not for the everyday power-plant employee. This is by no means a reflection on the work, but is intended to suggest to readers of "Power" further inquiry or inspection at a public library before purchasing the book to make sure of its utility in their particular line of study. Students of chemistry and those employed in chemical laboratories are not likely to err in purchasing the book.

Personals

W. L. Schaeffer, who has been assistant manager of advertising with the National Tube Co., has been appointed manager of the department, to succeed L. F. Hamilton, resigned.

Joseph H. Brown, formerly assistant manager of the Sullivan Machinery Co.'s New York Office, is now district sales manager at Chicago, succeeding P. J. Dinsmoor, resigned.

John J. Calahan, supervising engineer, Board of Education, Jersey City, has been appointed instructor in mathematics and steam engineering to the evening classes in the William N. Dickinson High School, Jersey City.

W. F. Trenary, Jr., with headquarters at 419 Brown-Marx Building, Birmingham, Ala., now represents the Harrison Safety Boiler Works, of Philadelphia, succeeding W. R. Jennison, whose connection with that company has terminated.

L. F. Hamilton, for the last nine years manager of the advertising and specialty department of the National Tube Co., of Pittsburgh, Penn., resigned on Dec. 1 to join the Walworth Manufacturing Co., of Boston, to take up similar duties.

E. E. Jones, who was with the Peerless Rubber Manufacturing Co., has been appointed superintendent of power plants with the Union Traction Co., of Indiana. He will have charge of power plants at Anderson, New Castle, Winchester, Eaton and Portland.

Wallace T. Roberts, formerly sales engineer for the Sullivan Machinery Co., in lower Michigan, northern Ohio and Indiana, is now district manager at the company's Denver office, succeeding Captain Matt R. Blish, who is serving in the United States Ordnance Department.

Joseph McKay, Jr., for thirteen years with the Wheeler Condenser and Engineering Co. and for the last two years with the Pittsburgh Valve Foundry and Construction Co., has recently been engaged as general sales manager of the Deschanel Engineering Corp., 90 West Street, New York City.

Miscellaneous News

State Fuel Administrators have been instructed by the United States Fuel Administrator that they have complete authority in their respective states to enforce the proper distribution of the coal supply at proper prices. Under these instructions the state administrators will have full authority to make all regulations regarding local distribution.

Project to Develop 100,000 Hp.—A gigantic plan to harness the waters of the upper Kings River with power plants to generate sufficient electricity for use in the San Joaquin valley and southern California for years to come, an undertaking that will total many millions of dollars, has been announced by A. G. Wishon, general manager of the San Joaquin Light and Power Corporation. The harnessing of these waters may eventually develop 100,000 hp., three times as much as is now being generated from the seven hydraulic plants of the San Joaquin.

The Three Big Generators of the Electrical Development Co. at Niagara Falls being idle, full capacity of its plant in Toronto is not yet utilized. Canadian munitions plants are short of power and the Hydro is unable to meet needs. The demand for power, too, in the Niagara district is 60 per cent. in excess of what it was a year ago and the supply is 40 per cent. less than at that time. A gathering of municipalities recently took place in Toronto, when it developed that one company, which was deliberately shortening the power supply, was looking for long-term contracts with users of power at a higher rate.

Engineering Affairs

Elmer E. Chambers Council No. 5 of the Universal Craftsmen Council of Engineers of New York tendered a reception to Grand Worthy Chief Elmer E. Terry, of Toronto, on Saturday evening, Nov. 24. The Corinthian room of Terrace Garden was comfortably filled by members of No. 5 and delegations from near-by councils. The regular business session concluded with the installation of seven members, all of them being from the Navy Department. The evening's fun concluded with an amusing entertainment. Worthy Chief L. E. Kenny was the master of ceremonies. Mr. Terry will visit several of the councils before his departure for home.

Trade Catalogs

"Powell" Grease Cups. The William Powell Co., Cincinnati, Ohio. Booklet. Pp. 20; 3½ x 6 in.; illustrated. Sectional views and descriptions of a complete line of automatic grease cups are given.

Snow Oil Pumps. Worthington Pump and Machinery Corporation, 115 Broadway, New York. Bulletin S-112. Pp. 24; 6 x 9 in.; illustrated. Gives complete numbered lists of the parts of these pumps, with line cuts of same.

Compressors and Vacuum Pumps for Extraction of Gasoline from Natural Gas. Ingersoll-Rand Co., 11 Broadway, New York. Form No. 3118. Pp. 32; 6 x 9 in.; illustrated. Gives a brief description of the gasoline-extraction process and a diagrammatic sketch of an extraction plant.

Hydro Pressure and Draft Recorders. Bacharach Industrial Instrument Co., 422 First Ave., Pittsburgh, Penn. Catalog D. Pp. 8; 6 x 9 in.; illustrated. Explains the design and construction of these recorders and their use and application.

The Steam Motor. The Steam Motors Co., Inc., Myrick Building, Springfield, Mass. Pp. 16; 6 x 9 in.; fully illustrated. Describes the application, details of the design, flexibility, specifications, etc., of type "B" units. New York agent, F. E. Pratt, 30 Church St.

Zelnicker's Bulletin No. 226. Locomotives, tanks, pipe, plates, journal boxes and wedges, road rollers, wire rope, girders and beams, steel piling, etc. The bulletin also shows views of the Zelnicker organization and the facilities that make good service possible. Walter A. Zelnicker Supply Co., 325 Locust St., St. Louis, Mo.

Business Items

The Vulcan Soot Cleaner Co. has received an order for one hundred cleaners for boiler plants in ten of the properties of Henry L. Doherty & Co.

The Badenhausen Co. is building extensions to its Norristown and Bridgeport (Penn.) plants, and is building a new plant at Cornwells, Pennsylvania.

The Chicago Superheater Co., an Illinois corporation, has been formed to engage in the manufacture of locomotive, marine and stationary superheaters, also independently stoker-fired superheaters. Charles F. O'Connell is president and treasurer, Edward A. Geoghegan is vice-president and mechanical engineer, and N. L. O'Connell is secretary. The company's offices are in the First National Bank Building, 38 South Dearborn St., Chicago, Ill.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Nov. 30, 1917	One Year Ago	Nov. 30, 1917	One Year Ago
Buckwheat ..	$4.98—5.20	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.40—4.65	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	.....	.....	.....	.....
Barley	3.90—4.15	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Nov. 30, 1917	One Year Ago	Nov. 30, 1917	One Year Ago
Clearfields....	.....	$3.00	.....	$4.25—5.00
Cambrias and Somersets..	.....	3.10—3.85	.....	4.60—5.40

Note—Bituminous not on market.

Pocahontas and New River, f.o.b. Hampton Roads, is $4, as compared with $2.85—2.90 a year ago; on cars Boston price is $8.50—8.75.

*All-rail rate to Boston is $2.69. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Nov. 30, 1917	One Year Ago	Nov. 30, 1917	One Year Ago
Buckwheat ..	$3.95—4.65	$2.75	$5.10—5.30	$4.25—4.50
Rice	3.40—3.60	2.20	3.80—4.10	3.00—3.25
Barley	2.90—3.15	1.95	3.00—3.30	2.10—2.25

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. N. Y. Harbor	Mine
Pennsylvania	$3.65	$2.00
Maryland	3.65	2.00
West Virginia (short rate).....	3.65	2.00

Based on Government price of $2 per ton at mine.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Nov. 30, 1917	One Year Ago	Nov. 30, 1917	One Year Ago
Buckwheat ...	$2.90	$2.00	$3.80	$2.90
Rice	2.40	1.25	3.40	2.15
Boiler	2.20	1.10	3.30	2.00
Barley	1.90	1.00	2.15	1.90

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Nov. 30, 1917	One Year Ago
Slack	$3.00—3.25	$4.50—4.75
Mine-run	3.00—3.25	5.00
¾-in.	3.50—3.75	3.35—3.85

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Counties Williamson and Franklin	Harrisburg Saline and	Smokeless West Virginia	Field Spring-	Counties Clinton and Sullivan
Steam lump ..	$2.65	$2.65	$2.70	$2.65	$2.65
Lump	2.65	2.65	2.70	2.65	2.65
Egg	2.65	2.65	2.70	2.65	2.65
Nut	2.65	2.65	2.70	2.65	2.65
No. 1 nut....	2.65	2.65	2.70	2.65	2.65
No. 2 nut....	2.65	2.65	2.70	2.65	2.65
No. 3 nut....	2.65	2.65	2.70	2.65	2.65
No. 1 washed.	2.65	2.65	2.70	2.65	2.65
No. 2 washed.	2.65	2.65	2.70	2.65	2.65
Mine-run	2.40	2.40	2.40	2.40	2.40
Screenings	2.15	2.15	2.20	2.15	2.15

Hocking lump, $2.60; splint lump, $2.40.

Northern Illinois thin vein—Prepared sizes, $2.65; mine-run, $2.40; screenings, $2.15.

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Nov. 30, 1917	One Year Ago	Nov. 30, 1917	One Year Ago	Nov. 30, 1917	One Year Ago
6-in. lump ..	$2.80	$3.00	$2.80*	$3.00	$2.80	$3.00
2-in. lump ..	2.80	3.00	2.80*	3.00	2.80	3.00
Steam egg...	2.80	3.00	2.80*	3.00	2.80	3.00
Mine-run	2.55	3.00	2.55*	3.00	2.55	3.00
No. 1 nut....	2.80	3.00	2.80*	3.00	2.80	3.00
2-in. screen..	2.30	3.00	2.30*	3.00	2.30	3.00
No. 5 washed	2.30	2.50	2.30*	2.50	2.30	2.50

*Strike.

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump and Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona....	2.15	2.40	1.90
Black Creek, Cahaba ...	2.40	2.65	2.15

Government figures.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ariz., Williams—The Town voted in favor of a $35,000 bond issue for the erection of an electric-lighting plant.

Ont., Eugenia—The Hydro-Electric Power Commission is having plans prepared for the erection of an addition to its power plant.

Calif., Mare Island—(Vallejo P. O.)—(Official)—Bureau of Supplies and Accounts, Navy Dept., Wash., soon receives bids for furnishing at Navy Yard, Mare Island, under Schedule No. 1571, brass hose bibb cocks; steam and water, composition bushings, couplings, fittings; steam and water brass valves.

Conn., Norwich—The Eastern Connecticut Power Co., recently organized with a capital stock of $1,500,000, plans to build a large steam plant at Thamesville; equipment for generating electricity will also be installed.

D. C., Wash.—(Official)—Bureau of Supplies and Accounts, Navy Dept., Wash., soon receives bids for furnishing at Navy Yard, under Schedule No. 1573, seamless-drawn brass tubing.

Ill., East St. Louis—B. Gratz, care of American Manufacturing Co., 1026 South 11th St., St. Louis, Mo., is having plans prepared by Klipstein & Rathman, Arch., Chemical Bldg., St. Louis, Mo., for a 1-story, 60 x 80-ft. power plant. Estimated cost, $40,000.

Kan., Chanute—City is having plans prepared by Black & Veatch, Engrs., 607 Inter-State Bldg., Kansas City, Mo., for improvements to its boiler plant. Estimated cost, $20,000.

N. J., East Orange—The Sprague Electric Co., East Orange, plans to construct a new 1-story power plant in connection with its motor manufacturing plant. Estimated cost, $20,000.

N. J., Newark—Bd. Educ., 45 Alexander St., plans to build a new 1-story, 18 x 52-ft. boiler room. Estimated cost, $15,937.

N. Y., New York—(Borough of Brooklyn)—(Official)—Bureau of Supplies and Accounts, Navy Dept., Wash., soon receives bids for furnishing at Navy Yard, Brooklyn, under Schedule No. 1575, 2000 4-in. x 18-ft. boiler tubes; under Schedule No. 1576, voice, seamless, hard-drawn, brass tubing.

Ohio, Lowellville—The Mahoning & Shenango Railway and Light Co., a subsidiary of the Republic Railway and Light Co., 15 Exchange Pl., Jersey City, N. J., recently sold $500,000 bonds for the completion of its power plant here.

Okla., Hennessy—The Oklahoma Gas and Electric Co. has been granted permission to erect and maintain an electric transmission and distributing system. J. L. Murphy, Pres. Bd. Trustees.

Penn., Allenport—The Pittsburgh Steel Products Co., Frick Annex, Pittsburgh, plans to build a 1-story, 30 x 85-ft. substation in connection with its plant here. Estimated cost, $15,000.

Tex., Dallas—The Dallas Power and Light Co., 1504 Commercial St., plans to install new machinery in its power plant. E. Oram, Engr.

Tex., Uvalde—The Uvalde Electric Light Co., Uvalde, plans to enlarge its plant and provide power for pumping water for irrigation purposes.

Tex., Victoria—City is having plans prepared by A. Garcia, Arch., for the erection of an underground conduit system. Estimated cost, $40,000. Noted Aug. 7.

Va., Norfolk—(Official)—Bureau of Supplies and Accounts, Navy Dept., Wash., soon receives bids for furnishing at Navy Yard, Norfolk, under Schedule No. 1576, voice, seamless, hard-drawn brass tubing.

Wash., Puget Sound—(Bremerton P. O.)—(Official)—Bureau of Supplies and Accounts, Navy Dept., Wash., soon receives bids for furnishing at Navy Yard, Puget Sound, under Schedule No. 1584, steam and water, malleable iron fittings; steam and water composition unions; under Schedule No. 1588, steam and water composition couplings bushings; 240 plain bibb brass cocks; 72 steam and water brass cocks; steam and water, cast-iron lock nuts.

Wis., Marathon—The Wisconsin Valley Electric Co., Wausau, has been granted a franchise for the erection of an electric-lighting plant here.

Wis., Milwaukee—The Milwaukee Public Sewerage Commission plans to build a steam generating plant for the new public sewage disposal system now being built. Estimated cost, $800,000. T. Chalkley Hatton, Ch. Engr.

Wis., Oostburg—The Denmark Condensed Milk Co., Denmark, has had plans prepared by F. T. Benton, Arch., Green Bay, for a 1-story, 40 x 60-ft. brick and steel boiler and engine room.

B. C., Delta—The Municipal Council plans to install an electric pump in the pump house which will soon be erected. Estimated cost, $12,000.

Ont., Blenheim—The Empire Flour Mills Co., Blenheim, plans to install considerable electrical equipment to operate its elevator and choppers.

Ont., Toronto—The Dunlop Tire and Rubber Co., Ltd., 224 Booth Ave., plans to build an addition to its power plant. Estimated cost, $7000.

Que., Coleraine—The Bennett-Martin Asbestos Mines, Ltd., Coleraine, is in the market for electrical equipment including three 400-kva. 44,000-2400-volt transformers, one 650-hp., one 275-hp. and one 150-hp. sling-ring type motors with several smaller motors and transformers and a switchboard for the control of this equipment. M. A. Sammett, 211 McGill St., Montreal, Consult. Engr.

Prices—Materials and Supplies

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

ELECTRICAL SUPPLIES

KNIFE SWITCHES—Following are net prices each in cities named for knife switches mounted on slate base, front connected, punched clip type, 250 volts:

	30 Amp.	60 Amp.	100 Amp.	200 Amp.
D. P. S. T. fuseless	$0.52	$0.93	$1.90	$3.42
D. P. S. T. fused	.81	1.37	2.70	5.14
D. P. D. T. fuseless	.88	1.52	3.42	5.70
D. P. D. T. fused	1.67	2.58	5.62	9.88
T. P. S. T. fuseless	.78	1.40	2.86	5.14
T. P. S. T. fused	1.22	2.05	4.18	7.70
T. P. D. T. fuseless	1.37	2.35	5.24	8.82
T. P. D. T. fused	2.68	4.13	8.99	15.80

Lots $25 and more, list.

FUSES—Following are net prices of 250-volt inclosed fuses each, in standard packages, in cities named:

0-30 amperes	$0.11¼ each	110-200 amperes	$0.90 each
31-60 amperes	.15¾ each	225-400 amperes	1.62 each
61-100 amperes	.40 each		

FUSE PLUGS (MICA CAP) PER 100

0-30 amperes.. 4c. each in standard package quantities (500)
0-30 amperes.. 5c. each for less than standard package quantities (500)

SOCKETS, B. B. FINISH—Following are net prices in cents each in standard packages:

⅛-IN. OR PENDANT CAP			⅜-IN. CAP		
Key	Keyless	Pull	Key	Keyless	Pull
22.10c.	21.00c.	42.00c.	27.30c.	26.20c.	46.20c.

Note—Less than standard package quantities, 15% off list.

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.18	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	....
T. P. S. B.	.81	1.80	...
D. P. D. B.	.78	2.10	...
T. P. D. B.	1.35	3.60	....
T. P. to D. P. D. B.	.90	2.52	...

ATTACHMENT PLUGS—Price each, in standard packages:

		Standard Package
Hubbell porcelain	$0.21	250
Hubbell composition	.12	50
Benjamin swivel	.12	...
Current taps	.35	50

CHRISTMAS TREE LIGHT OUTFITS—For 110-volt lighting circuits the price is as follows:

	Per Set
8-light outfit with colored lamps complete	$2.00
16-light outfit with colored lamps complete	4.00
24-light outfit with colored lamps complete	6.00
32-light outfit with colored lamps complete	8.00
For 3½-volt battery circuits:	
8-light outfit with colored lamps complete	1.50

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$21.50
No. 16 cotton twisted	29.00
No. 18 cotton parallel	24.00
No. 16 cotton parallel	36.00
No. 18 cotton reinforced heavy	28.50
No. 16 cotton reinforced heavy	39.40
No. 18 cotton reinforced light	24.00
No. 16 cotton reinforced light	32.00
No 18 cotton Canvasite cord	21.75
No. 16 cotton Canvasite cord	32.00

LOOM—Price per 100 ft., in coils:

	Ft. in Coil			Ft. in Coil	
¼	250	$2.25	¾	150	$7.00
⅜	250	3.50	1	100	10.00
½	200	4.50	1¼	100	12.00
¾	200	5.75	1½	100	15.00

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York.

No.	Solid, Single Braid	Solid, Double Braid	Stranded, Double Braid	Duplex
14	$11.00	$12.75	$16.00	$25.00
12	15.50	17.88	21.00	35.16
10	21.75	24.50	27.50	48.50
8	30.50	33.75	38.25	67.00
6	....	....	58.76	....
5	....	....	69.20	....
4	....	....	83.10	....
3	....	....	100.00	....
2	....	....	121.25	....
1	....	....	158.75	....
0	....	....	191.60	....
00	....	....	233.75	....
000	....	....	286.00	....
0000	....	....	349.50	....

COPPER WIRE—Prices per 1000 ft. for rubber-covered wire in following cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$12.25	$15.20	$29.75	$13.50	$18.00	$30.00	$12.50	$17.90	$36.80
10	24.50	27.70	54.95	27.25	30.10	....	30.30	34.30	67.60
8	34.90	38.50	76.80	38.45	42.45	....	42.85	46.85	....
6	....	59.10	....	....	65.35	....	69.60	74.10	....
4	....	85.15	....	....	93.65	....	101.75	106.50	....
2	....	127.50	....	....	140.50	....	156.50	163.00	....
1	....	165.35	....	....	182.50	....	201.00	209.00	....
0	....	198.55	....	....	241.50	....	276.00	285.50	....
00	....	267.05	....	....	294.50	....	317.00	330.00	....
000	....	327.35	....	....	360.50	....	417.00	428.50	....
0000	....	399.60	....	....	439.50	....	508.00	516.00	....

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per unit for elbows and couplings:

	Conduit		Elbows		Couplings	
In.	Enameled	Galvanized	Enameled	Galvanized	Enameled	Galvanized
½	$69.70	$74.80	$0.1672	$0.1786	$0.0616	$0.0658
¾	92.00	98.90	.22	.235	.088	.094
1	136.00	146.20	.3256	.3478	.1144	.1222
1¼	184.00	197.80	.4185	.4496	.1581	.1698
1½	220.00	236.50	.558	.5994	.1953	.2098
2	296.00	318.20	1.023	1.10	.2604	.2797
2½	468.00	503.10	1.674	1.80	.372	.3996
3	612.00	657.90	4.464	4.79	.558	.5994
3½	763.60	818.80	9.86	10.59	.744	.7992
4	926.50	991.90	11.39	12.23	.93	.999

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

LOCKNUTS AND BUSHINGS—Following are net prices in standard packages, which are: ½-in., 1000; ¾- to 1¼ in., 100; 1½- to 2-in., 50:

	Locknuts Per 100	Bushings Per 100	Flexible Conduit Box Connections Per 100
½	$1.02	$1.68	$5.62
¾	1.75	4.00	7.12
1	3.00	6.15	10.50
1¼	5.00	8.20	15.00
1½	7.50	10.25	22.50
2	10.00	16.40	30.00
2½	12.30	24.60	67.50

ARMORED CABLES AND BOX CONNECTORS—Following are net prices per 1000 ft. cable and standard package of 100 box connectors in single and double strip:

Wire Gage	Twin Conductor Cable	Twin Conductor Connectors	Three Conductor Cable	Three Conductor Connectors
14	$76.00	$4.50	$103.50	$4.50
12	101.25	4.50	127.50	4.50
10	138.75	4.75	176.25	4.75
8	176.20	5.75	247.50	6.00
6	277.50	6.25	362.40	7.50
4	431.25	7.50	....	....

LAMPS—Below are present quotations in less than standard package quantities:

	Straight-Side Bulbs			Pear-Shape Bulbs			
	Mazda B—			Mazda C—			
Watts	Plain	Frosted	No. in Package	Watts	Clear	Frosted	No. in Package
10	$0.27	$0.30	100	75	$0.65	$0.70	....
15	.27	.30	100	100	1.00	1.05	24
25	.27	.30	100	300	3.00	3.10	24
40	.27	.30	100	500	4.50	4.65	12
50	.27	.30	100	750	6.00	6.25	8
60	.36	.40	100	1000	7.00	7.25	8

Standard package quantities are 10% from above prices. Yearly contracts ranging from $150 up allow a discount of 17% from list.

WIRING SUPPLIES—New York prices for tape and solder are as follows:

Friction tape, ½-lb. rolls	35c. per lb.
Rubber tape, ½-lb. rolls	45c. per lb.
Wire solder, 50-lb. pools	35c. per lb.
Soldering paste, 1-lb. cans	50c. per lb.

MISCELLANEOUS

HOSE—

	Fire 50-Ft. Lengths
Underwriters' 2½-in.	75c. per ft.
Common, 2½-in.	40%

	Air		
	First Grade	Second Grade	Third Grade
¾-in., per ft.	$0.60	$0.35	$0.30

Steam—Discounts from list

First grade.... 30% Second grade.... 30% Third grade.... 40%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition ..... 50% Best grade 20%
Standard 35%

LEATHER BELTING—Present discounts from list in the following cities are as follows for cut lengths:

	Medium Grade	Heavy Grade
New York	40%	35%
St. Louis	45%	40%
Chicago	30+10%	40+5%
Birmingham	35%	40%
Denver	40%	40%

RAWHIDE LACING—40%.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.77
Asbestos for high-pressure steam	1.54
Duck and rubber for piston packing	.88
Flax, regular	.66
Flax, waterproofed	.99
Compressed asbestos sheet	.99
Wire insertion asbestos sheet	1.21
Rubber sheet	.55
Rubber sheet, wire insertion	.88
Rubber sheet, duck insertion	.44
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided, and graphited, for valve stems and stuffing boxes	1.10
Asbestos wick, ½- and 1-lb. balls	.65 to .70

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard Thickness Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure ..... 15% off

For low-pressure heating and return lines { 4-ply ..... 58% off; 3-ply ..... 60% off; 2-ply ..... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Chicago	St. Louis	Birmingham	Denver
Cup	5¼	5.6	10½	10½
Fiber or sponge	6	5.9	15	15
Transmission	6	5.9	13	13
Axle	4	3.3	4	4
Gear	4½	6	5½	5½
Car journal	3½	3.75	5	5

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Nov. 28, 1917	One Year Ago	Cleveland	Chicago
White	11.00 to 13.00	10.00 to 12.00	16.00	14.00 to 15.00
Colored mixed	8.50 to 12.00	7.00 to 9.00	14.00	10.00 to 12.00

WIPING CLOTHS—In Cleveland the jobbers' price per 1000 is as follows:

13¼ x 13¼ ..... $35.00 13¼ x 20½ $45.00

In Chicago they sell at $30@33 per 1000.

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago	
	Nov. 28, 1917	1 Year Ago	Nov. 28, 1917	1 Year Ago	Nov. 28, 1917	1 Year Ago
Raw, in barrels	$1.20	$1.01	$1.25	$1.05	$1.18	$0.96
5-gal. cans	1.30	1.11	1.40	1.15	1.28	1.06

WHITE AND RED LEAD in 500-lb. lots sell as follows in cents per pound:

	Red				White			
	Nov. 28, 1917		1 Year Ago		Nov. 28, 1917		1 Yr. Ago	
	Dry	In Oil	Dry	In Oil	Dry and In Oil		Dry and In Oil	
100-lb. keg	12.25	12.50	10.50	11.00	12.00		10.50	
25- and 50-lb. kegs	12.50	12.75	10.75	11.25	12.25		10.75	
12½-lb. keg	12.75	13.00	11.00	11.50	12.50		11.00	
1- to 5-lb. cans	14.25	14.50	12.50	12.50	14.50		12.50	

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅜ and smaller	30%	30%	40%*
Tinned	30%	30%	40%*

*For less than keg lots the discount is 35%.

Button heads, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York ..... $7.00 Cleveland ..... $6.85 Chicago $5.50

Coneheads, same sizes:

New York ..... $7.10 Cleveland ..... $6.95 Chicago $5.60

AMMONIA—Below are prices per lb. in cities named:

	New York	Chicago	St. Louis
26-deg. U.S.P. carboys of 100 lb.	16c.	12c.	....
26-deg. U.S.P. drums of 1000 lb.	14c.	10c.	12c.

Anhydrous ammonia in 100-lb. cylinders costs 30c. per lb. in St. Louis, Chicago and New York.

FIRE BRICK—Quotations on the different kinds in the cities named are as follows, f.o.b. works:

	New York	Chicago
Silica brick, per 1000	$50.00 to 55.00	$50.00
Fire clay brick, per 1000, No. 1	45.00 to 55.00	.....
Magnesite brick, per net ton	135.00 to 145.00	.....
Chrome brick, per net ton	135.00	.....
Deadburned magnesite brick, per net ton	85.00 to 90.00	.....
Special furnace chrome brick, per net ton	60.00 to 70.00	60.00 to 80.00

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—High grade, $55 to $65; St. Louis grade, $40 to $50.
Birmingham—Fire clay, $25 to $30; Denver, $23, per 1000.
Chicago—Second quality, $25 per ton.

FUEL OIL—Price variable, depending upon stock. New York quotations not available owing to this fact. In Chicago and St. Louis the following prices are quoted:

	Chicago	St. Louis
Mexican heavy, 12-14 Baumé	7c.	none
Domestic light, 22-26 Baumé	5½c.	7½c.

Note—There is practically no fuel oil in Chicago at present time.

OIL—Price per 50-gal. bbl. is as follows:

City	Fuel	Black	Red Engine	Steam Cylinder	Gasoline
Seattle	$1.60	$6.25	$11.00	$21.00	$10.25
Los Angeles	1.45	6.50	12.00	26.00	10.00
Denver	3.25	8.75	17.00	24.00	12.00
*St. Paul	3.00	5.50	11.00	17.50	10.05
Boston	6.00	11.00	16.00	23.00	12.50
Kansas City	7.20	5.20	10.50	17.85	10.15

Note—Standard prices of oil are necessarily difficult to give. Those above are for average grades.
*These are last month's quotations; current prices not available.

POLES—Prices on Western red cedar poles:

	New York	Chicago	St. Louis	Denver
6 in. by 30 ft.	$5.59	$4.94	$4.94	$4.32
7 in. by 30 ft.	7.40	6.60	6.60	5.80
7 in. by 35 ft.	10.70	9.60	9.60	8.55
8 in. by 35 ft.	12.20	10.90	10.90	9.65
7 in. by 40 ft.	12.35	11.00	11.00	9.75
8 in. by 40 ft.	13.75	12.15	12.15	10.65
8 in. by 45 ft.	18.20	16.20	16.20	14.30
8 in. by 50 ft.	21.85	19.45	19.45	17.15

PIPE—The following discounts are for carload lots f.o.b. Pittsburgh; basing card of Nov. 6, 1917, for steel pipe and for iron pipe:

BUTT WELD

Steel			Iron		
Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼ and ⅜	44%	17%	¾ to 1½	33%	17%
½	48%	33½%			
¾ to 3	51%	37½%			

LAP WELD

2	44%	31½%	2	26%	12%
2½ to 6	47%	34½%	2½ to 4	28%	15%
			4½ to 6	28%	15%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	40%	22½%	¾ to 1½	33%	18%
½	45%	36½%			
¾ to 1½	49%	36½%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	42%	30½%	2	27%	14%
2½ to 4	45%	33½%	2½ to 4	29%	17%
4½ to 6	44%	22½%	4½ to 6	28%	16%

Note—National Tube Co. quotes on basing card dated Apr. 1.

From warehouses at the places named the following discounts hold for steel pipe:

	Black		
	New York	Chicago	St. Louis
¾ to 3 in. butt welded	38%	42.8%	40.1%
3½ to 6 in. lap welded	18%	38.8%	36.1%

	Galvanized		
	New York	Chicago	St. Louis
¾ to 3 in. butt welded	22%	27.8%	25.1%
3½ to 6 in. butt welded	List	24.8%	22.1%

Malleable fittings, Class B and C, from New York stock sell at list price. Cast iron, standard sizes, 15 and 5%.

BOILER TUBES—Nominal discounts on less than carload lots freight added to point of delivery, effective from Nov. 1, 1916, on standard charcoal iron tubes and from Apr. 2, 1917, on lap-welded steel tubes are as follows:

Lap Welded Steel		Standard Charcoal Iron	
1¾ to 2	13%	1¾ to 1⅞	+35%
2¼	24%	2 to 2¼	+22½%
2½ to 3¼	17½%	2½ to 2¾	+ 7½%
3½ to 4½	13%	3 to 3¼	+ 5%
		3½ to 4½	12½%

Above discounts apply to standard gages and to even gages not more than four gages heavier than standard, in standard lengths. Locomotive and steamship special charcoal grades bring higher prices: 1¾ in., over 18 ft. and not exceeding 22 ft., 10 per cent. net extra; 2 in. and larger, over 22 ft., 10 per cent. net extra.

Note—Boiler tubes are practically out of the market. Can be obtained from the mill only on long promises of delivery. Customer will probably have to shop around until he finds a stock.